Session 1

Jump Into Design

Understanding the Design Process

In This Session:

A) Build a Better Paper Clip (60 minutes)
- Student Handout
- Student Reading

B) The Design Process (45 Minutes)
- Student Handout
- Student Reading

C) Toothpaste Cap Innovations (45 Minutes)
- Student Handout

Jump Into Design orients students to a design process that guides the work of engineers and designers. Three hands-on activities build understanding of the role of engineering and design in producing effective solutions to real-world problems.

In *1A: Build a Better Paper Clip* students carefully examine the form and function of standard paper clips. Given a set of wires and tools, they are challenged to design a new paper clip that meets predetermined requirements. This design challenge provides a firsthand connection with a 10-step design process that is introduced in a group activity, *1B: The Design Process*. The design process forms the foundation for work on students' own projects, and each step is revisited in greater depth in subsequent sessions. In the final hands-on design activity in this session, *1C: Toothpaste Cap Innovations*, students examine a designed solution to the problem of conventional screw-top toothpaste caps as they walk through the steps of the design process.

Supplies

- For each student: straight pins, safety pins, and a variety of different types of paper clips of varying sizes
- 20 feet (4 meters) each of 4 different types of wire cut into lengths of 1 foot (30 cm) for designing paper clips
- Several pairs of wire cutters and needle-nose pliers
- Stack of scratch paper to test solutions
- Additional materials for embellishment, such as beads, buttons, glue, etc.
- Toothpaste cap samples: screw top and flip-top cap
- Flip chart and markers, white board and markers, or computer to display discussion points
- Safety goggles

Jump Into Design

Key Concepts: Session 1

Throughout Session 1, students are introduced to the concept of design and engineering as a *formal process* through a series of hands-on activities. They begin with redesigning a simple object—the paper clip—in order to develop a common reference point as they begin their experience with **the design process**. Another product example follows and is used to practice and reinforce understanding. These experiences with the design process build the important foundation for the rest of the activities in *Design and Discovery* as the design process forms the basis of the curriculum.

Key Concepts

The Design Process: A systematic problem-solving strategy, with criteria and constraints, used to develop many possible solutions to solve a problem or satisfy human needs and wants and to winnow (narrow) down the possible solutions to one final choice.

The design process is a recognized set of generally defined steps designers and engineers use based on a problem-solving strategy that leads to product development. It begins with the identification of a problem through a series of exploratory and data-gathering stages, to the creation of a solution. Though the process is introduced as a series of sequential steps, it is important to understand that the process is not truly linear—it is much more like a design *cycle* since many of the steps are intended to be revisited as more information is gathered. Because this forms the core of this curriculum, adults working with students must be comfortable with the process and how it plays out in the subsequent activities.

If you recall "the scientific method" you were introduced to in science classes, you will recognize the similarity of a sequenced set of steps, used as reference by professional scientists. There are natural and logical steps that facilitate the desired outcome. However, the scientific method and the design process are fundamentally different. While scientists propose a "solution" up front (the hypothesis) and then test it through experimentation to see if it is correct, designers identify the problem, define it as a design challenge, then brainstorm, research, gather data, and test to identify *what the correct solution should be*. The "solution" is arrived at later as a result of the process of data gathering and experimentation. Both represent the formal process used by each profession from each field, though inquiry and experimentation are at the heart of both.

Students are introduced to the design process in *1B Handout: The Design Process*. Become familiar with the steps.

1. **Identify a design opportunity.**
   The design process begins with identifying a need. Notice that opportunities to design a new product or redesign an existing one are everywhere. They often come from a

Key Concepts Session 1 (continued)

problem that has been experienced personally. The goal is to identify many design opportunities and narrow them down later.

2. **Research the design opportunity.**
   Gather a lot of information about the nature of the problem in order to help narrow down your choices. Find out if other people experience the same problem and research any existing products or solutions that may currently be used to solve the problem. Choose a design opportunity to address. Write a problem statement.

3. **Brainstorm possible solutions to the problem.**
   Try to come up with as many ideas as you can for solving the problem or addressing the design opportunity. Brainstorming may involve the use of SCAMPER and other techniques. Then, narrow down your solutions and choose one to three to pursue further.

4. **Draft a design brief.**
   Write a design brief to help outline the problem. A design brief includes a problem statement, a description of the user needs, a proposed solution, and often a sketch of the idea or solution. This is a working document that can be changed.

5. **Research and refine your solution.**
   Do a literature review and talk to experts in related fields and users to find similar solutions and other approaches to the problem. Analyze your solution for feasibility, safety, and practicality.

6. **Prepare design requirements and conceptual drawings.**
   Define the criteria the solution must meet (design requirements) and sketch conceptual drawings.

7. **Build models and component parts.**
   Analyze the project design for its systems, components, and parts. Consider appropriate materials and methods for constructing a model. Now build a model of the entire design and/or its systems.

8. **Build a solution prototype.**
   Develop detailed project specifications, consider material properties required, choose materials, and create a working prototype.

9. **Test, evaluate, and revise your solution.**
   Evaluate the prototype for function, feasibility, safety, aesthetics, and other criteria. Consider how it could be improved. Modify your prototype or create another and test it.

10. **Communicate the solution.**
    Present your design solution to an audience. Gather feedback and revise and redesign your product as necessary.

More About the Design Process

Garratt, James. *Design and Technology*. New York: Cambridge University Press, 1993.

Petroski, Henry. *Invention by Design; How Engineers Get From Thought to Thing*. Cambridge: MA: Harvard University Press, 1998.

Petroski, Henry. *To Engineer Is Human: The Role of Failure in Successful Design*. Reprint, New York: Vintage Books, 1992.

Technology Student, www.technologystudent.com*
This site supports the UK's Design Technology course. The information covers a wide range of topics, including the design process, electronics, and gear systems.

Session 1, Activity A
Build a Better Paper Clip

Goal
Experience the design process by re-engineering an everyday object.

Outcome
Design and engineer a new paper clip that meets requirements.

Description
After careful observations of how different kinds of paper clips function and perform, participants design a new paper clip that meets several requirements including a unique look. They construct them using a selection of materials and prepare drawings of the various designs. Each designer presents a new paper clip model.

Supplies
- For each student: straight pins, safety pins, and a variety of different types of paper clips of varying sizes
- 20 feet (4 meters) each of 3 or 4 different types of wire cut into lengths of 1 foot (30 cm) for designing paper clips
- Several pairs of wire cutters and needle-nose pliers
- Stack of scratch paper to test solutions
- Additional materials for embellishment, such as beads, buttons, superglue, etc.
- Safety goggles

Safety Guidelines
Safety goggles should be worn during this activity when either you or the student is cutting wire.

Note About Wire
Wire needs to be flexible but have sufficient springiness to retain its shape after some bending. Recommended: Steel or copper wire, 14 or 18 gauge. Floral stem wire (18 gauge steel) is available in craft stores and floral shops.

Preparation
1. Read *1A Reading: The Perfect Paper Clip.*
2. Optional: Invite mentors to the first activity. Review the mentor section in Implementation for more information on mentors.

1A: Build a Better Paper Clip (continued)

Procedures

Introduction

1. Introduce students to their design notebooks. Remind students that the notebook is a place to record ideas, inspirations, discoveries, sketches, and notes. They will begin using the design notebook in this first activity to record their thoughts and ideas. Some general guidelines include:
   - Leave a few pages blank at the beginning to create a table of contents.
   - Date and sign each page.
   - Number each page.
   - Never remove pages.
   - Do not erase.

2. Mentors could be brought in and assigned to students during this activity. They offer the ability to provide guidance and prompt discussion while the students are designing their paper clip.

3. At the start of this activity, identify the problem by introducing students to the Design Challenge: The owners of P&C Office Supplies are seeking new designs for paper clips. The company has come across hard times and believes a new paper clip design could revive its once-thriving business. It is up to you to save their company. Use your imagination and creativity to invent a new paper clip design. After researching their paper clip sales pattern, the owners have come up with requirements for the design. Please refer to them before you begin. (Refer to the handout with the design requirements, and allow time for students to read it thoroughly.)

4. Describe the materials and tools for the design challenge. Discuss the different types of wire the students will be using and what is meant by wire gauge—the size of the wire's diameter. The higher the gauge number, the smaller the diameter and the thinner the wire. Pay special attention to the needle-nose pliers and wire cutters. Some students may not have experience with these tools. Take time to show students the correct way to hold and use the tools. Review the requirements with students before they begin brainstorming solutions to the design challenge.

5. Before students begin designing a new paper clip, they should explore the existing designs you have provided and make observations in their design notebooks. Remind them that all these fasteners represent different solutions to the same problem—holding papers together.

1A: Build a Better Paper Clip (continued)

Exploration

1. Encourage students to experiment carefully with all the examples provided, exploring the ability of various materials to hold paper.

2. Remind students to make sketches and take notes about their observations of different materials and paper clip designs in their design notebooks.

3. Move among the students and discuss their observations about the materials and the extent to which different materials bend and spring back, retaining the ability to "hold" materials (evidence of Hooke's Law).

Design

1. Monitor progress to allow at least 25 minutes for designing, engineering, and testing a new paper clip prototype.

2. Remind the students to draw quick sketches in their design notebooks of their ideas and note test results.

Supplementary Information

Paper Clip History

The radio show, "Voices of Innovation" (www.voicesofinnovation.org*), provides listeners with two-minute sound portraits of engineering wonders and the people who developed them. These sound clips can be downloaded and played for students.

The following clips talk about the invention of the paper clip:

- www.voicesofinnovation.org/archives/Sept_02/P17_9_24_02.asp*

The Early Office Museum (www.officemuseum.com/paper_clips.htm*) provides a brief written history of the paper clip and a gallery showing early paper clip designs.

Paper Clips and Hooke's Law

Robert Hooke, a contemporary of Sir Isaac Newton, was an early advocate of the microscope. He examined things like the points of needles and edges of razor blades, noting the qualities of objects and thus making suggestions for improvements in their performance. He also identified what has come to be called Hooke's Law: *Ut tensio sic vis* (Latin) which means, "As the extension so the force." Each object stretches in proportion to the force applied to it. The more we stretch something, the more resistance it offers in response. In engineering, this law is

1A: Build a Better Paper Clip (continued)

applied to airplane wings, bridges, skyscrapers, and paper clips.

Read more about paper clips and Hookes Law: Petroski, Henry. *The Evolution of Useful Things: How Everyday Artifacts—From Forks and Pins to Paper Clips and Zippers—Came to be as They Are.* Chapter 4: From Pins to Paper Clips. New York: Vintage Books, 1992.

Wrap Up
Each student presents a brief explanation and demonstration of his or her paper clip design. Have students read *1A Reading: The Perfect Paper Clip*, an excerpt from *Invention by Design* by Henry Petroski. This can be done as a group, reading sections out loud, time permitting. Otherwise, students can take it home to read.

Follow With
In the next activity, *1B: The Design Process*, students become familiar with the design process which they will use throughout the sessions.

Build a Better Paper Clip

Handout: Session 1, Activity A

Exploration of Existing Paper Clips
Explore the paper clips and pins (two types of fasteners) that you have in front of you. Pins were used to fasten paper together before the invention of the paper clip. Pay close attention to your hands and fingers as you use each one to fasten together pieces of paper. What do you notice?

You might notice the action needed to separate the paper clip loops so it slips onto the papers, or the way your fingers direct the clip onto the papers. Each of these actions is unconscious, and the ease with which the object is used indicates a successful design.

Explore the properties of the shape and the materials of each paper clip design. Observe the operation of each design, make notes about each, and apply what you learn to designing a unique, new paper clip. What is common about the way each shape works to do the job? What properties in the material allow each to do the job of fastening paper together?

Investigation of Materials and Tools
Investigate the materials and tools provided to you. Notice the different types of wire. The wire's diameter is measured in order to determine its gauge. The higher the gauge number, the smaller the diameter and the thinner the wire. The needle-nose pliers may be used to bend the wire into specific shapes.

Design Challenge

The owners of P&C Office Supplies are seeking new designs for paper clips. The company has come across hard times and believes a new paper clip design could revive its once thriving business. It is up to you to save their company. Use your imagination and creativity to invent a new paper clip design. After researching their paper clip sales pattern, the owners have come up with requirements for the design. Please refer to them before you begin.

Try out all your ideas and make drawings of your designs. Choose one design to engineer and test. Be prepared to present your model.

Requirements

- Your paper clip will be unique. It cannot look like any paper clip you have ever seen before, but it may have features of other clips.
- It can be no bigger than 2 inches by 2 inches (5 cm x 5 cm).
- It must hold 10 pieces of paper together.
- You may use other materials to enhance your design, but your main material must be wire.

- It must not have sharp ends.
- You should use your design notebook to draw your various designs.

You may use this square to test for the paper clip size requirement.

The Perfect Paper Clip

Reading: Session 1, Activity A

Why in the world would you study a paper clip as you learn about engineering and design? Henry Petroski, a professor of civil engineering, has written many interesting books about design and engineering in everyday things. In his book, *Invention by Design*, he devotes a whole chapter to paper clips. He notes that the paper clip, although one of the simplest of objects, can provide many lessons about the nature of engineering.

We take paper clips for granted—it seems as if they've always been around. In fact, they've been in use only since the time of the Industrial Revolution. Before that, paper was held together with straight pins. However, the straight pin was difficult to thread through more than a few sheets of paper because it left holes in the paper, and it bulked up piles of paper.

With the developments of the Industrial Revolution, however, volumes of paper increased as technology enabled business to expand nationally and internationally. The paper clip had a clear advantage over the straight pin in holding together a group of papers, and eliminated pricked fingers! The increase in technology associated with the Industrial Revolution also allowed paper clips to be produced in quantities that kept the cost per clip low.

Early versions of the paper clip had problems that later versions sought to remedy. The paper clip we know and love today, with its (almost) perfect design, did not start out that way. Earlier models got tangled together, slipped off too easily, had too much "springiness" or not enough...

As Henry Petroski notes, the paper clip we are familiar with works because:

"... its loops can be spread apart just enough to get it around some papers, and when released, can spring back to grab the papers and hold them. This springing action, more than its shape per se, is what makes the paper clip work. Springiness, and its limits, are also critical for paper clips to be made in the first place."

The most successful paper clip yet designed is the Gem* clip. The shape of the Gem clip was introduced in England in the late 19th century by a company known as Gem, Limited. The classic Gem has certain proportions that seem to be "just right."

Petroski quotes an architecture critic who had the Gem in mind when he wrote:

"Could there possibly be anything better than a paper clip to do the job that a paper clip does? The common paper clip is light, inexpensive, strong, easy to use, and quite good-looking. There is a neatness of line to it that could not violate the ethos of any purist. One could not really improve on the paper clip, and the innumerable attempts to try—such awkward, larger plastic clips in various colors, or paper clips with square instead of rounded ends—only underscore the quality of the real things."

1A Reading: The Perfect Paper Clip (continued)

The Gem became to paper clips what Kleenex* is to facial tissue because of a patent issued to William Middlebrook, of Waterbury, Connecticut, in 1899. The unique aspect of Middlebrook's patent was that, although there were many inventors patenting all sorts of sizes and shapes of paper clips, Middlebrook was patenting the machine that would form the paper clip economically.

Petroski writes:

"The complexity of Middlebrook's machine is clear from his patent drawings, and it is apparent that he was engaged in serious mechanical engineering…The principles upon which the machine works, bending wire around pegs, are well suited to the Gem design and it to them. In short, Middlebrook's machine and the Gem were made for each other."

So the combination of a well-designed paper clip and a well-designed machine led to the success of the Gem clip today.

The architecture critic aside, many believe that even the Gem could use improvement: It goes on only one way; it doesn't just slip on; it doesn't always stay on; it tears the papers; it doesn't hold many papers well.

This is what makes engineering and inventing so challenging. All design involves conflicting objectives and thus compromise. The best designs will always be those that come up with the best compromise.

Of course, inventors will always look for ways to improve upon an object. They will continue to look for ways to make a better paper clip. Newer clips, for instance, may be plastic coated, or shaped like Gems, yet their proportions never seem to be quite right. One improvement to the paper clip has been the introduction of a turned-up lip on the end of the inner loop. This allows the paper clip to slide onto the papers without actually opening the clip. As mentioned above, design involves tradeoffs. This "improvement" adds to the bulk of bundled papers.

One key point to remember is that the laws of nature always bind invention, design, engineering, and manufacturing. Change in one area of design may lead to design weakness in another.

To inventors, the quest for the perfect paper clip remains elusive. Perhaps the simple paper clip isn't so simple a device after all!

Adapted from:
Petroski, Henry. *Invention by Design: How Engineers Get from Thought to Thing.* Cambridge, MA: Harvard University Press, 1996.

Session 1, Activity B

The Design Process

Goal

Become familiar with the design process.

Outcome

The experience with designing paper clips is formalized into a design process that guides students throughout their design and engineering projects.

Description

A small group discussion of the paper clip design activity collects the students' experiences with the design process they experienced directly. The discussion moves to connecting their experience to a general design process outlined on *1B Handout: The Design Process*. A short reading that clarifies the relationship among design, engineering, and scientific research wraps up the activity.

Supplies

Flip chart and markers, white board and markers, or computer to display discussion points.

Preparation

Set up flip chart and markers, white board and markers, or computer to display discussion points.

Procedures

Brief Discussion

1. Ask students to reflect on their experience with designing a new paper clip. You might prompt them to think about:
    - What gave them their ideas?
    - What stages or steps did they go through as their ideas took shape?
    - What helped them move their idea into a prototype?

2. Ask students to share their experience with their designs. Have each person share. Make quick notes on flip chart paper or white board. Call attention to areas of common experiences.

Design Process Review

1. Look at the *1B Handout: The Design Process*, and have students take turns reading each step out loud.

1B: The Design Process (continued)

2. Discuss any connections between the students' experience and the design process as you go through each step.

3. Emphasize that the design process consists of several steps that are revisited throughout the stages of designing a product. The process may go through cycles as ideas are refined and information is gathered. Reinforce the idea that mistakes and failures are part of the process and can help develop a better solution to a problem.

4. Introduce the idea that students will be using this process to identify a need that could be met by redesigning, modifying, or improving an existing product or designing a new product.

Wrap Up
Ask participants to look around the room and discuss:

- What things in the room were designed?
- Which ones were engineered?
- Why do people design things?
- What frustrations do you have with products you use?
- How would you improve those products?

Follow With
The *1C: Toothpaste Cap Innovations* activity walks students through the design process using a designed solution to the problems of conventional screw-top toothpaste caps.

The Design Process

Handout: Session 1, Activity B

Getting From "Think" to "Thing"

You will be using a design process to guide the development of your project from an idea to the design of a prototype. The steps of the design process are iterative, or cyclical. That means that throughout the stages of designing a product, you will revisit many of these steps as you refine your ideas.

1. **Identify a design opportunity.**
   The design process begins with identifying a need. Notice that opportunities to design a new product or redesign an existing one are everywhere. They often come from a problem that has been experienced personally. The goal is to identify many design opportunities and narrow them down later.

2. **Research the design opportunity.**
   Gather a lot of information about the nature of the problem in order to help narrow down your choices. Find out if other people experience the same problem and research any existing products or solutions that may currently be used to solve the problem. Choose a design opportunity to address. Write a problem statement.

3. **Brainstorm possible solutions to the problem.**
   Try to come up with as many ideas as you can for solving the problem or addressing the design opportunity. Brainstorming may involve the use of SCAMPER and other techniques. Then, narrow down your solutions and choose one to three to pursue further.

4. **Draft a design brief.**
   Write a design brief to help outline the problem. A design brief includes a problem statement, a description of the user needs, a proposed solution, and often a sketch of the idea or solution. This is a working document that can be changed.

5. **Research and refine your solution.**
   Do a literature review and talk to experts in related fields and users to find similar solutions and other approaches to the problem. Analyze your solution for feasibility, safety, and practicality.

6. **Prepare design requirements and conceptual drawings.**
   Define the criteria the solution must meet (design requirements) and sketch conceptual drawings.

7. **Build models and component parts.**
   Analyze the project design for its systems, components, and parts. Consider

1B Handout: The Design Process (continued)

appropriate materials and methods for constructing a model. Now build a model of the entire design and/or its systems.

8. **Build a solution prototype.**
   Develop detailed project specifications, consider material properties required, choose materials, and create a working prototype.

9. **Test, evaluate, and revise your solution.**
   Evaluate the prototype for function, feasibility, safety, aesthetics, and other criteria. Consider how it could be improved. Modify your prototype or create another and test it.

10. **Communicate the solution.**
    Present your design solution to an audience. Gather feedback and revise and redesign your product as necessary.

Form Follows Function—What Does That Mean?

Reading: Session 1, Activity B

"The scientist seeks to understand what is; the engineer seeks to create what never was."
—attributed to Theodore Von Karman, engineer (1881-1963)

Every thing is supposed to function—it's supposed to do something, to work. Engineering is about function: Does the product work? Does it meet specifications? Can it be manufactured efficiently? All of this involves solving problems. We are going to be problem solvers and create things that function; we will think like engineers.

We will also learn the skills of good industrial designers. 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. How effectively something *functions* is often related to its *form*, or the quality of its design. Designers are concerned with qualities such as ease of use, efficient operation, and appealing aesthetics. We will pay attention to form in our project development. Though we will not focus on packaging design or marketing aesthetics, we will talk about the subtle but powerful influences of the "visual attraction" and "tactile appeal" of a product. Our goals are to meet an identified need with an idea that could work.

Science, Engineering, and Design: Where Do They Intersect?
While both engineers and scientists experiment and research problems, they differ in the kind of problems they work on. Engineers tend to work on problems that are of immediate concern to many people's daily lives. Scientific problems often build on basic understanding and may not have an immediate application in daily life.

The work of designers and engineers overlaps as well. Both seek to develop solutions to specific and immediate problems and needs. While design is involved in the entire process, engineering is the more specific process of making the idea meet specifications and function. One is useless without the other.

The First Step to a Good Design Is a Good Description of the Real Problem
The ability to really see a need, and then be able to describe that need, is at the heart of successful product development. It requires a heightened awareness of the way people use things, and an ability to observe one's surroundings. Watching for difficulties people experience in doing a task, or how a particular product is used in an unintended way, takes practice and skill. Our job will be to learn to watch for opportunities for improving a tool or product.

Session 1, Activity C
Toothpaste Cap Innovations

Goal
A thorough review of the design process.

Outcome
Experience with each step of the design process.

Description
This activity takes students through each step of the design process by focusing on the problem of toothpaste screw caps. This is started in a whole-group think-and-discuss format. Students may then work with a partner to complete remaining steps.

Supplies
- Toothpaste tubes with flip-top cap (1-2 for each group)
- Toothpaste tubes with screw cap (1-2 for each group)
- Other examples of toothpaste containers (1-2 for each group)

Preparation
None

Procedures
The Process

1. Walk through the design process using the toothpaste screw cap as the identified problem. Use the questions on the handout to guide discussion. Work with the whole group on steps 1 to 3.

2. Have students work with a partner on steps 4 to 10.

3. Below is a sample of how the handout could be filled out. This activity can either be open-ended, where the students come up with their own designs for a toothpaste cap, or it can focus on the development of the flip-top cap as a design solution. The sample "answers," which reflect the development of the flip-top cap, can be used to prompt students during the activity.

1C: Toothpaste Cap Innovations (continued)

Sample Responses

1. **Identify a design opportunity.**
   What is the problem or need? Describe in detail.

   The toothpaste screw cap poses many problems for people. When taken off, the cap may be easily dropped into the sink drain, on the dirty floor, or even into the toilet. The cap is usually placed on the sink and often leaves toothpaste on surfaces. Furthermore, toothpaste usually gets onto the exterior of the cap. If the cap has grooves in it, it is difficult to clean, which means that the next person to use the toothpaste will end up with toothpaste on her hands.

2. **Research the design opportunity.**
   What is important to know about the nature of this problem? Who are the "users" in this case? How could you find out more about the "users" and their behavior?

   In this case, the users are those who use toothpaste—everyone. However, a younger person might have different complaints about the cap than an older person. User information could be gathered by observing family members' use of toothpaste, surveying, and interviewing people. A trip to the local pharmacy to see what else is on the market might be helpful, too.

3. **Brainstorm possible solutions to the problem.**
   What solutions can you come up with? Take five minutes to brainstorm as many ideas as you can for solving this problem.

   A flip-top cap, a pump, all-in-one toothbrush and toothpaste.

Steps 4 to 10 can be done in small groups or pairs. Students can complete the steps using the flip-top cap example or any of the other examples brainstormed together.

4. **Draft a design brief.**
   Clearly define the current situation or need in a "problem statement," and describe a proposed solution. This is just the first part of the design brief.

   The current most-popular toothpaste cap is a screw cap. This cap poses many problems for the users, including: the cap falling off and getting lost or dirty, the cap leaving toothpaste on the sink and on the outside of the cap. A flip-top cap could solve this solution. This cap would remain on the toothpaste tube so that it could not be lost or dropped. It would not be separately placed on the sink and would therefore not make the sink top dirty.

1C: Toothpaste Cap Innovations (continued)

5. **Research and refine your solution.**
   What questions would be needed to gather the right data? Have other people tried to solve this problem? Are some materials more appropriate than others? If so, what are they? What about manufacturing costs associated with your idea? How would you analyze solution for feasibility, safety, and implications of the idea?

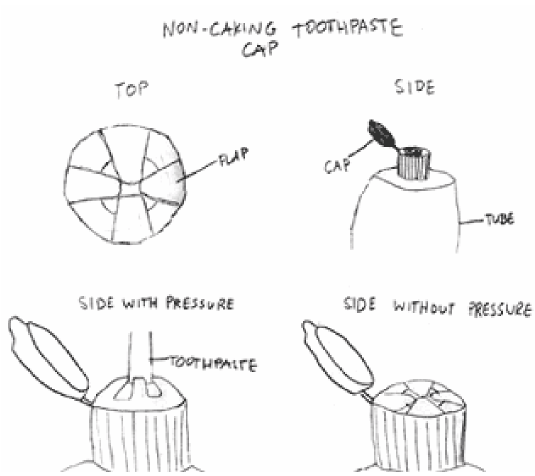
   I would need to do some research to see what types of toothpaste caps are out there. I might do a patent search, look online, go to the library, and browse the toothpaste aisle of the pharmacy. I would think that plastic would need to be used—something lightweight, cheap (it's disposable), and nontoxic. I think this product could be manufactured cheaply since many can be made at one time.

   I think it is feasible to make this product since it is similar to what is already on the market. In terms of safety, the cap would have to be able to screw on tightly so that it would not present a choking hazard to young children. It would have to open and close easily.

6. **Prepare design requirements and conceptual drawings.**
   Outline design requirements—general ways the product will meet the need of the users—and draw a quick sketch of your best ideas here.

   The cap would need to:

- *Fit on a standard toothpaste tube*
- Have an attached flip-top cap
- *Screw on to the tube*
- *Create an even flow of toothpaste*
- *Be made of a lightweight, cheap, nontoxic material*
- *Be leakproof*



1C: Toothpaste Cap Innovations (continued)

7. **Build models and component parts.**
   Does your solution have parts or components? What could you use to build a quick model of your best solution?

   A model could be built out of Styrofoam. The flip-top cap could be cut out of the Styrofoam and attached with a piece of rubber. The nozzle might be a separate component.

8. **Build the prototype.**
   What are the specifications for the product? What materials would you need to build a prototype?

   The specifications for the flip-top cap are:
   - *Plastic top with 3/8 in. (1 cm) opening*
   - *Dispensing nozzle*
   - *Outer tube: 1 7/16 in. (3.5 cm) diameter*

9. **Test, evaluate, and revise your solution.**
   How would you test your prototypes? What criteria would be useful to evaluate the solution? How would you know if your solution was going to solve the problem? How can I improve my solution based on feedback from my testing?

   I would establish criteria, such as: It is easy to use, it stays clean, it stays sealed, and the toothpaste flows easily. I would conduct user-testing focus groups and observe how people used the product.

10. **Communicate the solution.**
    How would I present my design solution to an audience? How would I gather feedback from the audience?

    I would present my solution through a presentation to peers and community members or I would enter a local science and engineering fair. I would create a feedback form that I would hand out to my audience so I could capture their comments and questions and incorporate them into the next phase of revisions to my design solution.

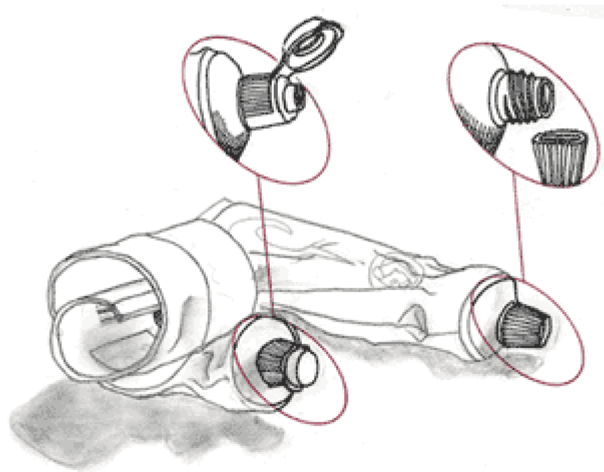
Wrap Up
Have teams describe their solutions or results of specific steps.

Follow With
In Session 2, *The Designed World*, participants learn how to look for design opportunities everywhere.

Toothpaste Cap Innovations

Handout: Session 1, Activity C

In this exercise you will have the opportunity to better understand the design process by applying it to a toothpaste cap. Currently, the most common toothpaste cap is the screw cap. However, many people are dissatisfied with this cap and would like an alternative. What else is on the market? What ideas can you come up with? The first question is done for you. As a group, you'll do the next three together. The remaining questions you will do on your own.



1. **Identify a design opportunity.**
   The toothpaste screw cap poses many problems for people. When taken off, the cap may be easily dropped into the sink drain, on the dirty floor, or even into the toilet. The cap is often placed on the sink and often leaves toothpaste on surfaces. Furthermore, toothpaste usually gets onto the exterior of the cap. If the cap has grooves in it, it is difficult to clean, which means that the next person to use the toothpaste will end up with it on her hands.

2. **Research the design opportunity.**
   What is important to know about the nature of this problem? Who are the "users" in this case? How could you find out more about the "users" and their behavior?

3. **Brainstorm possible solutions to the problem.**
   What solutions can you come up with? Take five minutes to brainstorm as many ideas as you can for solving this problem.

1C Handout: Toothpaste Cap Innovations (continued)

4. **Draft a design brief.**
   Clearly define the current situation or need in a "problem statement," and describe a proposed solution. This is just the beginning of the design brief.

5. **Research and refine your solution.**
   What questions would be needed to gather the right data? Have other people tried to solve this problem? Are some materials more appropriate than others? What are those materials? What about manufacturing costs associated with your idea? How would you analyze solution for feasibility, safety, and implications of the idea?

6. **Prepare design requirements and conceptual drawings.**
   Outline design requirements—general ways the product will meet the need of the users— and draw a quick sketch of your best ideas here.

7. **Build models and component parts.**
   Does your solution have parts or components? What could you use to build a quick model of your best solution?

8. **Build the prototype.**
   What are the specifications for the product? What materials would you need to build a prototype?

9. **Test, evaluate, and revise your solution.**
   How would you test your prototypes? What criteria would be useful to evaluate the solution? How would you know if your solution was going to solve the problem?

10. **Communicate the solution.**
    How would I present my design solution to an audience? How would I gather feedback from the audience?