The Design Process

Identify the Problem

At the beginning of each activity, students are asked to identify the problem that their designs will address. This step is important because it informs the rest of the design process and defines how success will be measured. The scenarios presented in the book vary. Some are true problems that need to be solved, such as how to safely filter water samples. Others focus on improving an existing design, such as building a device that allows students to flip a light switch from across the room. A handful are more conceptual in nature. For example, students would not be expected to design an actual dam and experiment with water flow to observe effects on the environment. The purpose of activities such as these is to help students understand some basic design concepts and apply those concepts to different problems or tasks.

Do Research

After a problem has been identified, students conduct research. This research may include finding articles in books, magazines, or on the Internet to help students begin to formulate ideas and recognize constraints for their designs. During this stage, students examine existing designs, which can provide a starting place and help students formulate questions. Research is also the step in which students discover and explore the important elements of a design. Guided questions encourage critical thinking about aspects of the problem that must be addressed in order to develop a successful design.

In each activity, the research step includes the question, *What are your design constraints?* This question helps students recognize the limits of their solutions and to eliminate solutions that would be inefficient, costly, or physically impossible.

Develop Possible Solutions

Next, students brainstorm possible design solutions that address the problem they identified. Possible solutions may include variations on one design using the same or different materials. They also may include completely different designs. This step allows students to recognize the pros and cons of each design.

Choose One Solution

In this step, students choose one of their proposed designs and describe it in detail. They may be asked to draw or diagram their design and to explain why they chose it. Having as much information as possible about each possible solution and keeping the problem or task in mind is helpful for choosing a successful design. The chosen design should represent the solution that students think best meets the need or solves the problem that was identified at the beginning of the design process.

Design and Construct a Prototype

At this point in the design process, students gather materials, build a prototype, and record the particular details of a design that are required for replication. These requirements—such as dimensions, measurements, materials, processes, and so on—are described in a detailed description or assessment. Anything that someone studying or replicating the prototype would need to know should be included in this section.

At the end of this step, students have a prototype that is ready for testing. By definition, a prototype is the original or base model. This concept is important for students' understanding of the design process and the fact that a successful prototype is not necessarily one without problems. Scientists usually change their prototypes multiple times before they get it to do what they want.

Test the Prototype

After building their prototypes, students will test it. Some of the activities produce prototypes that can be tested within a class period; others involve several days of testing. Students may be asked to construct graphs, tables, or to record their results in other ways. Testing the prototype usually involves asking questions that are based on observations, and assessing the prototype in terms of how well it solves the problem or task. Again, it is important for students to understand that a successful prototype is not a perfect prototype, but one that helps the designer refine his or her design.

Communicate Results

Sharing results is an important step in any developing design. Students are encouraged to use a variety of approaches to communicate their results. Examples include sketches, photographs, detailed diagrams, word descriptions, portfolios, computer simulations, computer slide shows, and video presentations. Students may also present evidence that was collected when the prototype was tested. This evidence may include mathematical representations, such as graphs and data tables, that support the design choice. Students can talk about how well a particular solution worked and learn how other students approached the problem.

It is important for students to understand that this step is not a competition. Communicating the results of an experiment or test has practical and ethical importance for scientists and engineers. Practically, communicating results opens a conversation in which other scientists or engineers can make suggestions and help improve a design. The design also might help the other engineers solve problems they are having with their own designs or inspire them with a new design. Ethically, communicating results opens an experiment or design to accurate, unbiased evaluation. It also helps protect the intellectual rights of the scientists or engineers sharing the design.

Evaluate and Redesign

The last step allows students to evaluate what worked and what did not work about their designs and why. Students are asked to rate their prototype designs with a rubric of design constraints. Students are encouraged to explain their ratings and, if needed, brainstorm design improvements. Some activities allow the students to redesign their prototype, but because of time and material constraints, other activities only engage students in a discussion.

The Design Process and Higher-Order Thinking Skills

Activity	Step in the Design Process	Critical Thinking Skills	Level of Difficulty	Teaching Tips
Questioning	Identify the Problem	Recalling, Understanding	Basic	Remind students that their designs will be based on the problem they identify and their research. Specificity and thoroughness are therefore paramount.
	Do Research			
Imagining	Develop Possible Solutions	Applying, Analyzing	Intermediate	Developing possible solutions is the brainstorming step. Remind students to use their research and consider their design constraints as they develop possible solutions but also encourage them to think outside the box.
Planning	Choose One Solution	Analyzing, Evaluating, Creating	Intermediate to Difficult	To assist students' choice of a design, you might help them create a checklist of characteristics that a successful design needs. However, students may have different reasons for choosing a solution. Allow students to choose less practical designs for experimentation and demonstration purposes.
Creating	Design and Construct a Prototype	Creating	Difficult	Remind students that a good design that is poorly executed will not produce favorable or accurate results. Taking time and being precise are important.
Evaluating	Test the Prototype	Applying, Analyzing, Evaluating, Creating	Intermediate to Difficult	Unsuccessful designs are to be expected. Treat them as learning opportunities as opposed to failures. Remind students that the design process might be more appropriately thought of as a cycle.
	Communicate Results			
	Evaluate and Redesign			

Name _____ Date _____

STEM

The Design Process

Engineers follow a process to make new products. The process begins with identifying a problem. Then engineers imagine, plan, create, and evaluate a product that addresses the problem.

Use this guide to develop solutions to problems you identify. Remember that engineers often revise prototypes many times, so you may carry out parts of the process several times when developing a solution.

1. Identify the Problem
Purpose: To recognize a specific issue that needs to be addressed
Ask yourself: What is the challenge? What needs to be improved? What is the need?

2. Do Research
Purpose: To gather information
Ask yourself: What questions do I have? What observations can I make? What solutions to the problem exist? How can they be improved? What materials are available? What is my solution limited by?

3. Develop Possible Solutions
Purpose: To think of several ways to solve the problem
Ask yourself: What are different ways to solve the problem? What materials are available? How can I use the available materials? What is my solution limited by?

4. Choose One Solution
Purpose: To decide which solution best solves the problem
Ask yourself: What are the strengths and weaknesses of each solution? Which solution is the most useful? Which solution is the least complicated? How will I develop my solution?

Name _____ Date _____

5. Design and Construct a Prototype
Purpose: To plan a design, gather materials, and build a model of your solution
Ask yourself: What materials do I need? How do I build a functional model? What are the special characteristics, or specifications, of my model?

6. Test the Prototype
Purpose: To see how well your design worked
Ask yourself: Did it work? Did it accomplish what I wanted it to do? Did anything else happen during my test that I didn't expect?

7. Communicate Results
Purpose*:* To share your results and learn from others
Ask yourself: How should I best communicate my results? Should I make a drawing and show people my prototype? How should I ask for others' feedback on my design?

8. Evaluate and Redesign
Purpose*:* To consider how to improve your design
Ask yourself*:* Did my design work the best that it could? How could I make it better? Is it practical? Are the materials cheap and easy to find? Does my solution create new problems, or the need for another new product? Will others be able to use it equally as well?