



Make It Work! Design Process

Clarify Challenge Among Team Members

Write a Goal Statement

Inventory Materials in Make It Work Design Kit

Brainstorm Design as a Team

Select / Vote on Best Design

Sketch Design on Engineering Graph Paper

Make a List of Materials from Design Kit to be Used

Build

Test

Redesign

Rebuild if Time Allows



The Make It Work! Design Process Defined

Goal Statement: (2 minutes) Students need to write down a simple goal statement that clearly defines the Design Challenge. If they ever get off track from what they are creating, they can refer back to the goal statement for clarity and guidance. Goal statements should ideally be one sentence and should be defined in only a minute or two. This is the first time the Team Leader needs to take charge of the challenge.

Inventory Materials: (3 minutes) In 3 minutes or less, students should quickly look through their Design Kit to see what materials are available for the Design Challenge. The Materials Engineer should lead this step.

Brainstorm ideas and Vote on the best one: (5 minutes) Team Leaders should take charge to listen to ideas of their team mates. Instruct Team Leaders that when brainstorming, **NO** idea is a bad idea. All ideas should be taken into account and then the Team Leader should lead a vote to select the best idea. Once an idea is selected, all team members need to be on board to make the idea a success. Brainstorming should take no more than 5 minutes.

Sketch Design and List Materials: (5 minutes) Time for the Graphic Designer to step up to the plate and draw a sketch of the design. Some students may not be comfortable drawing because they feel that they cannot draw well but they should be encouraged by the Team Leader to do their best. They also should list all the materials (with quantities) that the team has agreed to use in the design. Sketching and listing materials should take no more than 5 minutes.

Build: (20 minutes) Okay, now the fun begins! Team Leaders need to make sure that everyone is engaged in building the agreed upon design. **No one person should take over the build!** It is the Team Leader's responsibility to make sure that this does not happen. Teams should refer to the sketch and the Materials Engineer should pull out all the materials needed for the design. The Quality Control Engineer needs to make sure the design is built as shown in the sketch and that it will work. The build should take no more than 20 minutes.

Test: (10 minutes) While students are building, the instructor sets up the testing area taking every effort to be safe. Only one testing area is typically needed. As teams finish the build, they can take their design to the testing area for testing. Instructors need to ensure goggles are worn when needed and that no students place themselves in an unsafe situation where they could hurt themselves or others. Testing for all teams should take no more than 10 minutes. Once students have tested their design, they can disassemble the design if it was successful or start over with a redesign if they were not.

Redesign and Rebuild: (as time allows) Teams should only redesign and rebuild if their design was unsuccessful and if time allows. Team Leaders should lead this exercise by having their teams regroup and begin again at the top of the Design Process.



Make It Work! Job Descriptions

Jobs will rotate for each challenge. Have Fun!

1. Team Leader

The term, Team Leader, is used to emphasize the cooperative nature of the *Make it Work* team. The *Make it Work* Team Leader provides guidance, instruction, and direction to the rest of the team to ensure every member is actively engaged in creating a design and constructing the engineering challenge as stated. The *Make it Work* Team Leader should listen constructively to the rest of the team and make the final decision if all are not in agreement on a particular topic. Typical average salary of an engineering team leader in the working world = \$79,000

2. Graphic Designer

A real life Graphic Designer creates and/or organizes drawn, painted, photographed, or computer generated pictures into attractive and informative print designs such as gum wrappers, magazine covers, websites, product advertisements, signs, or t-shirts to name just a few. The *Make it Work* Graphic Designer will be responsible for writing the team's Goal Statement on graph paper. They will also draw the initial sketch of the team's design for the particular engineering challenge and draw any redesign sketches. The *Make it Work* Graphic Designer will write the list of materials on the graph paper working with the Materials Engineer once materials are selected. Typical average salary of a graphic designer in the working world = \$60,000

3. Materials Engineer

Material Engineers design and test a variety of materials to be used in the production of items from skateboards to space ships. They also develop new ways to use materials. The *Make it Work* Materials Engineer will inventory materials in the *Make it Work Design Kit* and suggest possible choices for the engineering challenge at hand. They will brainstorm with other team members how to use the different materials in ways that would allow for optimum outcome. The *Make it Work* Materials Engineer will work closely with the *Make it Work* Graphic Designer to ensure materials to be used are included in the sketch and are listed on the list of materials to be used for the challenge. Typical average salary of a materials engineer in the working world = \$83,000

4. Quality Control Engineer

A Quality Control Engineer oversees the production and construction of a specific design to ensure that it is built without defects and with a high level of quality. The *Make it Work* Quality Control Engineer is responsible to ensure that the design constructed by the team is structurally sound and safe and will not fall apart during testing. Finding defects before the testing phase can save the team time and the necessity to redesign. Any defects detected by the *Make it Work* Quality Control Engineer should be immediately referred to the *Make it Work* Team Leader. The Quality Control Engineer should lead the testing phase of the Design Challenge. Typical average salary of a quality control engineer in the working world = \$67,000



Challenge #1: Life Boat

Design Challenge:

You are on a sinking ship and need to rapidly design and build a lifeboat. The lifeboat needs to hold a maximum amount of passengers while remaining afloat. Design and build a lifeboat that holds the most passengers (represented by pennies) possible. Make sure you are one of them.



Instructor Notes

Items not provided for this Design Challenge:

- towels to put under testing bins
- paper towels

Instructor Testing Materials Needed from Teacher Design Kit:

- graph paper
- 500 pennies
- 2 large clear plastic bins (approximately 24"l x 17"w x 6"h) half filled with water placed on towels

Instructor Summary:

- Students will work together as a team to design and build a lifeboat to hold as many passengers (represented by pennies) as possible using the *Make it Work!* Design Process.
- Do not help students. They must use their problem solving and critical-thinking skills to find a solution to the challenge.
- Students will discover the principles of naval architecture by learning through doing.

Rules and Design Process:

- Each team will receive a Student MAKE IT WORK! Design Kit and graph paper
- Teams may use all or part of the materials provided
- Teams must follow the Design Process:
 - 1) Write a goal statement (2 minutes)
 - 2) Inventory materials (3 minutes)
 - 3) Brainstorm ideas and vote on the best one (5 minutes)
 - 4) Sketch design and list materials to be used on graph paper (5 minutes)
 - 5) Build (20 minutes)
 - 6) Test (10 minutes)
 - 7) Redesign and rebuild (if time allows)

Opening

- Take attendance
- Hand out Student Design Kits
- Hand out 1-2 pieces of graph paper per team
- Choose a student to lead the *Make it Work!* Oath
- Have students decide their roles on the team



Start it Up!

1. Have one student read the Design Challenge.
2. Tell Design Teams that today they are going to become naval architects. A naval architect is an engineer who is responsible for the design, construction, and/or repair of ships, boats, other marine vessels, and offshore structures, both commercial and military. Naval architects have a specialist function to ensure that a safe, economic, and seaworthy design is produced. To undertake all these tasks, a naval architect must have an understanding of many branches of engineering and must be in the forefront of high technology areas. He or she must be able to effectively utilize the services provided by scientists, lawyers, accountants, and business people of many kinds. Naval architects typically work for shipyards, ship owners, design firms, equipment manufacturers, and governments. Today they will work for themselves and their shipmates as they endeavor to save lives on a sinking ship!
3. Tell Design Teams they now have 2 minutes to write a Goal Statement. You may share the instructor goal statement for this first Design Challenge:

Build a lifeboat to hold the maximum number of passengers possible.

4. Instruct Design Teams to inventory their materials. Time them for 3 minutes.
5. Instruct Design Teams to brainstorm ideas about the design of their "lifeboat" and vote on the best one. Tell them they have 5 minutes to complete this process. Keep track of time for them and announce when time is up.
6. Design Teams now have 5 minutes to sketch their design and list the materials they are going to use (with quantities if they know them). Time teams.
7. Call time up and give Design Teams the go ahead to begin building. Design Teams may use anything in their Design Kits to complete their design. They have 20 minutes maximum to finish building.
8. If at any time a Design Team finishes a task before the time allotted, they may continue on to the next task on their own.

Testing the Designs

1. While students are building their design, you should set up the testing area unless you already set it up before class began.
2. Lay out towels on separate tables from where students are working.
3. Half fill the large, clear bins with water and place them on the towels.
4. Have pennies ready for students to load test their design.
5. As students finish building their designs, they should bring them over to the bins and place them in the water.
6. The Team Quality Control Engineer (not you) should add pennies to test the "lifeboat" and count them to see how many they can add before it begins to sink or take on water.
7. If a "lifeboat" does not float well, encourage the Design Team to go back and redesign and rebuild their boat as time allows.