Science and Innovation

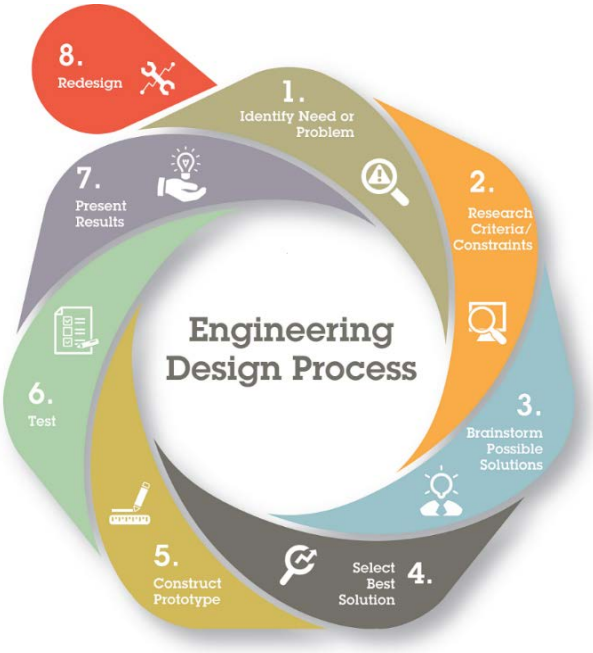
A Boeing/Teaching Channel Partnership

SPY GLIDERS

Student Handbook

Tch TeachingChannel®

Engineering Design Process



Step 1 Identify the Need or Problem

Describe the engineering design challenge to be solved. Include the limits and constraints, customer description, and an explanation of why solving this challenge is important.

Step 2 Research Criteria and Constraints

Research how others have solved this or similar problems, and discover what materials have been used. Be sure to thoroughly research the limitations and design requirements for success.

Step 3 Brainstorm Possible Solutions

Use your knowledge and creativity to generate as many solutions as possible. During this brainstorming stage, do not reject any ideas.

Step 4 Select the Best Solution

Each team member presents their solution ideas to the team. Team members annotate how each solution does or does not meet each design requirement. The team then agrees on a solution, or combination of solutions, that best meets the design requirements.

Step 5 Construct a Prototype

Develop an operating version of the solution.

Step 6 Test

Test your solution. Annotate the results from each test to share with your team.

Step 7 Present Results

Present the results from each test to the team.

Step 8 Redesign

Determine a redesign to address failure points and/or design improvements. The design process involves multiple iterations and redesigns. Redesign is based on the data from your tests, your team discussions as to the next steps to improve the design, and the engineering design process Steps 1 through 7.

Once your team is confident of a prototype solution, you present the results to the client. The client may:

- Accept your solution as is, or
- Ask for additional constraints and criteria to be included in the solution. At this point, you and your team revisit the engineering design process and resume the iterative redesign cycle.

1.1: Define the Problem

Engineering Design Challenge:

Think, Pair, Share

What questions would you need to have answered to clearly define this design task's criteria and constraints?

Write **at least** three of your own questions:

1.

2.

3.

Share your questions with your shoulder partner. Write down at least two more questions you came up with.

1.

2.

1.2: Criteria and Constraints

Criteria	Constraints

2.1: How Planes Fly

Initial Model

In the space below, develop an initial model to show how airplanes can fly. Use words, pictures, or diagrams. Focus on explaining how an airplane can fly. Try to identify the forces involved.

2.2: How Objects Fly

Stations

Station #1: Tent with a Straw

Follow the steps and respond to the questions.

1. Fold a 20 cm by 13 cm piece of paper in half to make a tent.
2. Place the paper tent on the desk.
3. Using a straw, blow under the tent and observe what happens.
4. Blow harder and observe what happens.
5. Try blowing hard against the side of the tent and observe what happens.

What happened?

How can you explain this?

Station #2: Ball and Straw

Follow the steps and respond to the questions.

1. Bend a flexible straw so the short end is pointing up.
2. Hold a ping pong ball over the opening of the straw and blow.
3. Let go of the ball and observe what happens.

What happened?

How can you explain this?

Station #3: Paper Paper

Follow the steps and respond to the questions.

1. Hold two pieces of notebook paper in front of you about 5 cm apart.
2. Blow hard between the papers and observe what happens.

What happened?

How can you explain this?

Station #4: Paper Helicopters

Follow the steps and respond to the questions.

1. Obtain a premade paper helicopter.
2. Drop the helicopter from a height and notice how it falls.
3. Change the shape/direction of the blades.
4. Does this change the direction or speed of the rotation?
5. What is making this rotate?

What happened?

How can you explain this?

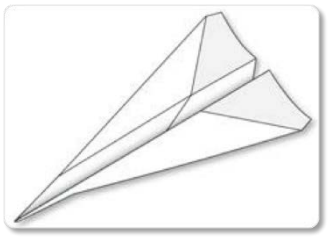
2.3: How Planes Fly

Revised Model

In the space below, develop a revised model to show how airplanes can fly. Use words, pictures, or diagrams. Focus on explaining how an airplane can fly. Include evidence from the 2.2: How Objects Fly: Stations investigations.

2.4: How to Make an Airplane Fly

1. Sketch a paper airplane design that you think will travel the furthest.



2. Explain why you think your airplane will travel the furthest. What features will help extend the flight of your airplane?

3. Use a blank sheet of paper to create your paper airplane. Write your name on your plane. Any preflight tests will be disqualified. **Don't throw it yet!**

4. Predict whose plane will travel the furthest. Include your reasoning.

2.5: Design Strengths and Failure Points

1. Sketch each glider.
2. Use color pencils to make predictions about design strengths and failure points of each glider.
3. After your test flights, use a pencil to write revised design strengths and failure points.

Glider		
Sketch		
Design Strengths		
Failure Points		

2.6: How Planes Fly
Final Model

In the space below, develop a final model to show how airplanes can fly. Use words, pictures, or diagrams. Focus on explaining how an airplane can fly. Include evidence from the 2.2: How Objects Fly: Stations investigations and from your prototype paper airplanes.

3.1: How Weight Affects Flight

Group Roles: We are used to working in our lab groups. Engineers also have roles when they work in groups on design tasks. Take a few minutes to discuss and choose a role for each member of your group. Put each person's name in the appropriate box.

Project Director (PD)

The project director is responsible for the group.

- Reads directions to the group
- Keeps the group on-task
- Confers with the teacher when needed
- Shares summary of group work/results with the class

_____

Recorder

The recorder is in charge of recording all data.

- Records data in tables and/or graphs
- Completes conclusions/final summaries
- Keeps ongoing qualitative and quantitative notes

_____

Material Manager (MM)

The material manager is responsible for obtaining all materials for the lab.

- Picks up needed materials
- Organizes materials in the work space
- Facilitates use of materials during investigation
- Returns all materials at the end of lab

_____

Safety Director (SD)

The safety director is responsible for enforcing all safety rules and conducting lab

- Assists PD with keeping group on-task
- Reports any accident to the teacher
- Keeps track of time
- Reminds others of safety guidelines

_____

3.2: How Weight Affects Flight

Payloads

Our finished gliders will need to carry the extra weight of the payload. Our payload weighs_____ g.

Design Task

Adapt a glider to travel a certain distance _____ while carrying a certain number _____of washers.

How many washers can your glider carry and still travel a certain distance_____?

Where on the glider should you place the washers?

Brainstorm! Sketch at least 3 ideas of where and how to attach the washers.

3.3: How Weight Affects Flight

Systematic Process

Now you must evaluate competing design solutions using a systematic process to determine the best solution to the design challenge. Another way of saying this is, how are you going to decide which solution is best in an organized way?

What steps would you need to take to be systematic about your design tests?

1.
2.
3.
4.
5.
6.

What data do you need to collect in order to make design revisions using a systematic process?

-
-
-
-
-

How will you decide which features of a design to keep and which to change?

-
-
-
-
-

3.4: How Weight Affects Flight

Work Space

4.1: Materials Warm Up

People have been trying to make flying machines for hundreds of years.

- What are the properties of materials used to make a successful glider?
- What materials would you like to use to create your final glider?

4.2: Controlled Investigation: Materials Testing

Question: Which material is the strongest and lightest? Which material is the best combination of weight and strength?

Hypothesis

Procedure

Labeled Diagram

5.1: Materials Testing Data Table

Material	Weight (g)	Strength (N)	Pro	Con

Results

5.2: Materials Debrief

Which material or composite material do you think you should use for your glider? Make sure to use both qualitative and quantitative evidence to strengthen your argument (your claim).

6.1: Build Day

Reread the criteria and constraints of the original design challenge. Draw a labeled diagram of what you think your final glider should look like. Make sure to note what materials will be used and where the payload will be placed.

6.2: Conceptual Model

1. Evaluate team members' proposed design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

2. Identify the best characteristics of each proposed design that can be combined into a new solution to best meet the criteria for success.

3. Create a poster of your proposed design. Your poster must include the following elements
    - **Materials**—What materials will you be using? How much will you need?
    - **Weight**—How much do you think your finished glider will weigh?
    - **Performance**—How will your glider meet the criteria and constraints of the task?
    - **Justification**—Provide evidence and reasoning for all design decisions.

4. Be prepared to present your proposal to the class.

5. Modify your conceptual model based on feedback from the group.

Describe your role in your group proposal. What struggles and strengths did you discover in working with your group?

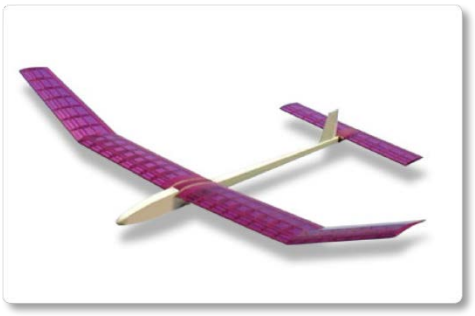
6.3: Build Day Debrief

Working together as a team can be particularly difficult when building or working on things with your hands.

- What strategies can you come up with to make sure that all of the members of your group are successfully contributing while building your glider?

8.1: Test Day

- Do you think any of the gliders we made will meet the criteria and constraints of our design challenge?
- Which glider do you think is going to be the most successful?
- What is your evidence and reasoning for your hypothesis?



8.2: Test Day

Data Table

Glider	Distance	Stability	Notes

9.1: Redesign and Retest

What were some of the design strengths and failure points of our gliders?

Design Strengths	Failure Points

9.2: Redesign and Retest

Data Table II

Glider	Distance	Stability	Notes

9.3: Optimal Design

Sometimes parts of different models can be combined to create a solution that is better than any of the models that came before.

- What are some of the similarities and differences among our models?
- What are the best characteristics of each model that can be combined into a new solution to better meet the criteria for success?

9.4: Analysis of Results