NICERC @ HOME

Computational Thinking
Paper Airplanes

This lesson explores mathematics and computational thinking in science and engineering through a classic aerospace lesson. Students will design, build, and test a paper airplane to see which one flies the farthest. Students will record data from their prototype test flights in a table and provide detailed written instructions on how to fold the paper airplane. Other participants will follow the instructions in an attempt to build an identical plane and get the same results.

Following the test flights of the second plane, students will compare the results of the first airplane to the second.

Are the results the same?

If not, what variable(s) could have affected the result?

How can the instructions be improved (using "repeat," measurements, and/or sketches)?

Why are detailed instructions important?

THE FOUR PILLARS OF COMPUTATIONAL THINKING

DECOMPOSITION

Students will break down the steps of folding a paper airplane in order to provide written instructions for another student to follow.

PATTERN RECOGNITION

While folding the prototype paper airplane, students will look for patterns such as repeated folds in the design.

ABSTRACT

Students will filter out unnecessary steps or information in the instructions and use "repeats" whenever appropriate.

ALGORITHM DESIGN

Students will organize and write out the steps to correctly fold a duplicate of the prototype paper airplane.

LEARNING GOALS

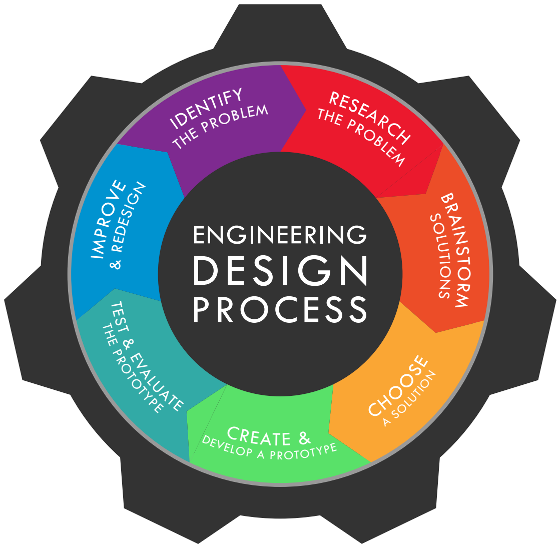
Students will use the science and engineering practices of mathematics and computational thinking to design an algorithm for how to fold a paper airplane.

VOCABULARY

Criteria, Constraints, Independent Variable, Dependent Variable, Controls, Lift, Drag, Thrust, Foil, Weight, Mass Production, Assembly Line

MATERIALS

8.5" X 11" piece of copy paper, internet



Step 1: Identifying the Problem

During World War II, between 1940 and 1945, 300,000 airplanes were built for the United States military. These airplanes were mass-produced using assembly line techniques. You will research the history of the assembly line, mass production of airplanes during World War II, and the principles of flight needed to design a paper airplane that can fly the farthest. The paper airplane that you design must have written instructions that allow it to be mass produced by your "classmates".

Engineers are guided in the engineering design process by criteria and constraints. **Criteria** are the goals that a project must achieve to be successful. **Constraints** are the limitations of the project design.

In this engineering design task, you are required to design a paper airplane from one unaltered standard sheet of copy paper (8.5 x 11 inches). You may not alter the paper by cutting it to reduce the size, adding flaps, or by adding tape, staples, or paper clips to secure the folds. The paper airplane you design should have the capability of consistent long-distance flights. You must provide detailed written instructions for your classmates to follow in order to mass-produce your paper airplane design. Your written instructions must include metric measurements and at least one "repeat."

In your own words, describe the problem. What are the criteria and constraints?

Step 2: Research the Problem

Topics to Research

- The history and importance of the assembly line
- Mass production of airplanes in WWII
- Principles of flight-lift
- Weight
- Drag
- Foil
- Thrust
- History of the paper airplane
- Rosie the Riveter
- Robots that assemble planes

Step 3: Brainstorm Solutions

Sketch and label your ideas on graphing paper. Include measurements (in metric units) and folds in your design. Identify how the principles of flight will be applied in your design sketch. We'll include paper with gridlines and sections for notes in case you don't have graph paper handy.

Step 4: Choose a Solution

Complete the following decision matrix to select the final paper airplane design for the prototype build. A decision matrix is a tool used by engineers to make decisions. When there are many alternatives and many criteria to be considered as a solution to the design problem, engineers will assign each design decision a value and rate the importance of each. A decision matrix will help guide engineers to a final design solution. Students will determine the weighted value of each category of the decision matrix either as a whole group or as teams. The group priority is a category to be determined either as a whole group or as a team.

	Can Fly Far	Can Be Mass Produced	Meets Criteria & Constraints	Consistent Performance	**Total Score**
Weight					
Design 1					
Design 2					
Design 3					
Design 4					

Decomposition - Students will break down the steps of folding a paper airplane in order to provide written instructions for another student group to follow.

Think:

- What design elements will be easiest to replicate for mass production yet will achieve the desired results?

Step 5: Identifying the Problem

Fold the prototype paper airplane.

Pattern Recognition - While folding the prototype paper airplane, encourage students to look for patterns, such as repeated folds, in their design.

Think:

- How can we use "repeats" in our written instructions?
- How might computer programmers use "repeats?"
- What is the value of using "repeats" in instructions or computer programs?"

STEP 6: Test & Evaluate the Prototype

Create a data table to record the results of your prototype test. (You may need to review how independent, dependent, and control variables function in an investigation.)
Perform the test and evaluate the prototype design.

Ask students:

- Did you get the desired results?
- Do you need to make any changes to the design before mass production?

Abstract - Students will filter out unnecessary steps or information in the instructions and use "repeats" whenever appropriate.

Independent variable - a variable whose values are specified first or before an investigation is performed and are used to find values, another variable, or a function that depends on the first variable
Dependent variable - mathematical variable whose value is determined by that of one or more other variables in an investigation
Control variable - the variable which is constant and unchanged throughout the investigatio
Data collection - the process of gathering appropriate information

Data analysis - making sense of data, finding patterns, and drawing conclusions
Data representation - depicting and organizing data in appropriate graphs, charts, words, or images
Abstraction - the reduction of complexity to define a main idea
Simulation - the representation or model of a process | Simulation also involves running experiments using models.

Algorithm Design - Students will organize and write out the steps to correctly fold a duplicate of the prototype paper airplane.

Algorithms and procedures - series of ordered steps taken to solve a problem or achieve some end.

Another student group will follow the written instructions to fold the paper airplane and will then test and collect data on the replica.

Automation - having computers or machines do repetitive or tedious tasks.

Step 7: Improve & Redesign

Student groups will offer feedback and suggestions for improvement based on the outcome of the test.

Ask:

- Were the instructions easy to follow?
- Did the replica plane achieve the same results as the prototype?
- Were all variables the same in the replica test?

Improve design and/or instructions based on consultation.

Presentation:

Students will present their final paper airplane design along with written instructions for mass production.

Challenge Activity:

After students have finished their presentations, have all participants mass-produce the paper airplanes using an assembly line. If possible, teams of students will form assembly lines, and each student will be assigned a portion of the build. The teacher will time the challenge activity. Students will compete to see which team can accurately build the most paper airplanes following the written instructions.

Parallelization - the organization of resources to simultaneously carry out tasks to reach a common goal.

DESIGN 1

NOTES:

DESIGN 2

NOTES:

DESIGN 3

NOTES:

DESIGN 4

NOTES: