Learning Lab
Paper Airplane Design

ESSENTIAL QUESTION—Where do you place the weight on the fuselage (choices: front, center, or back) so that the paper airplane will fly most accurately through the target?

Lesson Overview:
- Engage Section—students will create a class definition for the word, “stability.”
- Explore Section—students are introduced to the three axes of flight and the parts of an airplane that control these functions.
- Extend Section—students will use the scientific method to collect data to determine the best place to put weight on the fuselage for the paper airplane to fly most accurately through a target.
- Evaluate Section—students will analyze data collected to draw a conclusion regarding the Essential Question.

Basic Materials:
- Data and graph worksheet (one per student)
- Paper airplane worksheet (one per student)
- 1 large orange traffic cone
- Small cones (acts as taxiway and runway guidelines)
- Supplies: pencils, colored pencils, 1 small binder clip (or 3 paperclips) per student
- 1 Target (posterboard with a 12-inch hole works fine)

INSTRUCTIONAL PROCEDURE

Engage
1. As a class, have everyone stand up and ask the students if they are stable on one foot. Next, have the students stand on one foot. Then, have students stand on both feet while leaning forwards. Finally, have them stand on one foot while leaning forward. Ask the students if they are more or less stable on one foot than on two. Why? (Answers will vary.)
2. Take out the large orange traffic cone and place the flat end on the floor. Ask students if the cone is stable. Tell the students you are going to push on the cone and ask if it will be stable. The answer is yes since the cone does not fall. It goes back to its original position. Now turn the cone onto its point and ask the same question. Demonstrate that when it is disturbed, the cone falls over. This time the answer is no, the cone is not very stable on its point.

Background Information
- Stability refers to an airplane’s tendency to right itself after its flight path is disturbed. Center of lift is the point where all the lifting force can be assumed to be concentrated. Center of gravity is the “balancing point” of an airplane: at this point there is just as much mass in front of it as there is behind it. If you put your finger under the center of gravity, the plane will balance.

Instructional Objectives:
- Define the term stability as it relates to aircraft;
- Explain how weight affects the stability of an aircraft.
3. As a class, develop a working definition of stability by discussing balance in sports. Talk about balancing on a bicycle while turning and tie this into a brief discussion of the Wright Brothers. Mention that the Wright Brothers were bicycle engineers and knew that leaning into a turn was an important breakthrough in the discovery of flying an airplane. Discuss roll, yaw and pitch. Introduce the definitions for center of lift and center of gravity.

**Explore**

1. Introduce the scientific method, also referred to as experimental design. This may be a review for some classes.

2. Identify the parts of the experiment by asking the students, “What is a hypothesis?” Then, have them think about how using a binder clip as a weight will affect the flight depending on their placement. Remember, the goal is to have each of the airplanes fly through the target. Next, have the students create their own hypothesis by filling in the blank on the Data and Graph Worksheet. “Hypothesis: If the binder clip is placed on the _______ (choices: front, center, or back) of the fuselage, then the paper airplane will fly most accurately through the target.”

3. Review the terms independent and dependent variable. The independent variable is what will change and the dependent variable is what happens because of the change.

4. Once completed, start with identifying the independent variable (IV) which is the placement of the weight.

5. Have students develop the dependent variable (DV) which is how the airplane will fly. Next, list the constants for the experiment (same type of plane, same type of paper, same flying conditions, and the same target).

6. Now that the vocabulary has been defined and the experiment explained, pass out the airplane worksheets and fold your dart plane. To fold the airplane:
   a. Make folds in order from 1 to 4;
   b. Fold away on the solid black lines;
   c. Fold in on the dotted lines;
   d. Bend up the triangular wings so they are horizontal;

   Hint: Make sure that students are following your instructions carefully or the airplane will take on a different form. Remember, this is a constant and all airplanes must be the same design.

7. Go over the classroom expectations and procedures for flying airplanes in the room.

**Extend — Testing Hypothesis**

1. Have students place the binder clip at the front of the plane and line up to attempt to fly their plane through the target. Count how many planes make it through the target.

2. Record data on in the Data Table.

3. Repeat steps 1 and 2 with the binder clip at the center and then on the back.

**Evaluate — Analyzing Data**

1. Revisit the Essential Question.

2. Have students discuss and record data. Then, have students complete a bar graph on the worksheet. Discuss the scale and titles along the X and Y axis.

3. Tell students to write a one sentence conclusion. Call on students to share their findings with the class.

**Enhancements**

Students can use colored pencils to name and draw designs on their planes.
DATA AND GRAPH WORKSHEET

Hypothesis: If the binder clip is placed on the __________ of the fuselage, then the paper airplane will fly most accurately through the target.

DATA TABLE
The Effect of Binder Clip Placement on the Accuracy of Flight Through a Target

<table>
<thead>
<tr>
<th>Placement of Binder Clip</th>
<th>Total Number of Flights</th>
<th>Number of Successful Flights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Center</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GRAPH
The Effect of Binder Clip Placement on the Accuracy of Flight Through a Target

<table>
<thead>
<tr>
<th>Placement of Binder Clip</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRONT</td>
</tr>
</tbody>
</table>
