# Investigate Motion with Homemade Gliders

## Companion Lesson to X-STEM All Access Episode "High Altitude Inspiration"

| **Grade/ Grade Band 6-8** | **Topic:** Design Engineering | |
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| **Brief Lesson Description**: Captain Barrington Irving actually built the airplane he flew around the world. In this lesson, students explore how flight is possible and how engineers have improved aircraft designs and materials to improve flight accuracy and distance. Students explore the forces that make flight possible and learn about how material choice and shape impact flight. Student teams will design and test a simple glider using basic materials that can fly straight for 4.5 meters. | | |
| **Performance Expectation(s):**<br>**MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success**<br>**MS-PS2-2 Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object** | | |
| **Specific Learning Outcomes:**<br>Students will be able to design, test, and revise a device that glides through the air. | | |
| **Narrative / Background Information** | | |
| **Prior Student Knowledge:**<br>Students should be able to explain Newton's Laws of Motion<br>Students should be able to explain the forces that impact flight | | |
| **Science & Engineering Practices:**<br>**Analyzing and Interpreting Data**<br>Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.<br>● Analyze and interpret data to determine similarities and differences in findings.<br>**Planning and Carrying Out Investigations**<br>Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.<br>● Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how much data is needed to support a claim. (MS-PS2-2) | **Disciplinary Core Ideas:**<br>**ETS1.B: Developing Possible Solutions**<br>● There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.<br>● Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)<br>**ETS1.C: Optimizing the Design Solution**<br>● Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)<br>**PS2.A: Forces and Motion**<br>● The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2) | **Crosscutting Concepts:**<br>**Stability and Change**<br>● Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. (MS-PS2-2) |

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| | • All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS-PS2-2) | |

**Possible Preconceptions/Misconceptions:**
One misconception that students may hold is that heavier objects fall faster than lighter ones. In this experiment, students should understand that objects move downward with the same acceleration and there is another force, air resistance, acting on objects that is proportional to the area of the object.

**LESSON PLAN – 5-E Model**

**ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:**

Begin this lesson with a few questions to spark student interest: "would you like to participate in a Flying Classroom, what do you think you would be learning in the Flying Classroom?" Then show the High Altitude Inspiration video featuring Barrington Irving. After watching the video, students discuss what they learned about Captain Irving's Flying Classroom.

**EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:**
Prior to the lesson collect the following materials:

- Cardboard
- Construction paper
- Cardstock
- Foam sheets
- Foil
- Foam trays
- Paperclips
- Rubber bands
- Popsicle sticks
- Balsa wood
- Scotch tape
- Glue
- Scissors
- Rulers
- Plane Template/Jet Template (optional)

In advance create models of the plane and the jet using the templates (click photos for credits).

Tell students they are going to design and build a model plane that can travel 4.5 meters. Discuss with students what factors they think might affect the flight (shape, size, type of material). Depending on the students' level and knowledge of engineering design. In teams of 4 students will plan and sketch their plane, using the template if necessary. The plan should include the list of materials the team will use to construct the model.

Next is the construction phase of the lesson. Students will gather the materials they outlined in the design plan and build their aircraft.

After the have constructed the airplane, they should answer the following questions:

1. How similar is your airplane to your design template?
2. How did you decide which materials to select for final construction? What was it about the materials that you thought might help your airplane fly?
3. How did you decide on the shape of the parts of your airplane? What was it about the shape of each part that you thought might help your airplane fly?
4. Did you need to adjust or change your design once construction began? If so, describe the changes and explain why they were made.
5. Do you think that engineers often change their original plans during the manufacturing phase of development? How do you think this would impact the planned design or manufacturing budget?

**EXPLAIN: Concepts Explained and Vocabulary Defined:**
Define the four forces that impact flight: weight, lift, drag, and thrust. Weight is a result of gravitational forces. Inform students that the materials they design to use will have a weight that must be offset by the lift to fly. Lift is a force that helps to counteract weight and the heavier an object is the harder it is for lift to work against it. The thrust or velocity/forward motion will have an impact on the lift. The final force act on the aircraft will be drag, Drag is the force that acts opposite to the forward motion, and it is impacted by the thrust, the greater the thrust, the greater the drag.

Now ask students what parts of their planes do they think will impact the weight (type of material, size of plane), the lift (the material, shape of plane/wings), the thrust (how the person throws the plane), and the drag (the shape and material as well as the air temperature and humidity). Explain to students that these forces are interrelated and when they are in balance a plane will move at a constant velocity.
**Vocabulary:**
**Weight** is a result of gravitational forces
**Lift** is the sum of all forces on an object that force it to move perpendicular to the direction of flow (https://kids.kiddle.co/Lift_(force))
**Thrust** is the force which moves an aircraft through the air
**Drag** is the resistance force of air

**ELABORATE: Applications and Extensions:**
Prior to starting the elaboration section of this lesson, you will need to gather the following materials for the class:

- Cardboard
- Construction paper
- Cardstock
- Foam sheets
- Foil
- Foam trays
- Paperclips
- Rubber bands
- Pop sticks
- Balsa wood
- Scotch tape
- Glue
- Scissors
- Rulers

The Flight Test

Students will design the test for their aircraft. The purpose of the test is to ensure their model will consistently fly 4.5 m and should consist of at least 3 trials. Students will record data from the trials that includes distance flown, description of the path the aircraft flew in, and if the target was met.

Example:
Trial Ex.
Distance Flown: 3.5 m
Flight Path: Aircraft curved to the right
Target: Missed

After the three trials, students may make changes to their original design (i.e., alter shape, increase, or decrease weight, or change the person throwing the aircraft (thrust)). All teams repeat the test for 3 more trials and record observations.

For the final test, teams submit the aircrafts then the teacher will test them to maintain consistency. Students record the observations of each airplane tested and include notes about the differences in each other's designs.

Students then answer the following questions:

1. Did your aircraft land on the target?
2. What was the best aspect of your team's design? Describe why you believe it is the best feature.
3. Which aspect of the design did you change during the construction phase? During the testing phase? Explain why the team made the adjustments and if they worked to improve the aircraft.
4. Was there an aircraft that performed better than yours? If so, describe the differences between that aircraft and yours.
5. What changes would you make to improve your airplane based on the final flight tests?
6. What would you do differently if the aircraft needed to hit a target 9 m away? 2.25 m away?

**EVALUATE:**
**Formative Monitoring (Questioning / Discussion):** Students create a design plan and build their aircraft.

**Summative Assessment (Quiz / Project / Report):** Student responses to the questions will assess their understanding of the engineering design process and how the forces of flight interact.

**Elaborate Further / Reflect: Enrichment:** Students revise their designs and rebuild their airplanes to hit a target 2.25 m away or 9 m away.

**SOCIAL EMOTIONAL LEARNING ACTIVITY**

**CASEL Competency: SELF-MANAGEMENT**

Capt. Barrington Irving exhibits a great deal of perseverance. Explain to students that perseverance is the ability to continue with something even though it is difficult. Ask students to identify examples of Capt. Irving's perseverance (i.e., becoming a pilot, building an airplane, becoming the youngest to fly around the world, launching his nonprofit). Ask students to share an example of their perseverance.

Explain to students that perseverance is acutely aligned to self-management. Define self-management as the abilities to manage one's emotions, thoughts, and behaviors effectively in different situations and to achieve goals and aspirations.

In this activity students will practice self-management and perseverance through teamwork. For this activity you need the following materials for each team:
6 paper cups
1 rubber band
5 pieces of string (one per student in the group)

Directions:
1. Students are divided into groups of 5 and handed a piece of string.
2. Each student will tie their string to the rubber band.
3. Students will work together to stack their cups into a pyramid with 3 cups as the base, 2 cups in the middle and 1 cup at the top.
4. Give teams 10 minutes to build their pyramids using only their string and rubber band to move the cups.
5. At the end of 10 mins conduct a class discussion using the following prompt questions:
    a. Did your team achieve the pyramid? Why or why not?
    b. Was anyone frustrated during this activity? How did you handle the frustration (yours or your teammates)?
    c. What did you learn about yourself and the group you worked with?
    d. How is this activity good practice for developing your self-management?

**INTERDISCIPLINARY CONNECTIONS/IDEAS**

Students are using reason abstractly (MP.2.7.EE.3) to determine the relationship between weight, lift, thrust, drag and the distance of flight.

**Materials Required for This Lesson/Activity**

| Quantity | Description |
|---|---|
| Per group | Cardboard boxes |
| Per group | Cardboard tubes |
| Per group | Foam sheets |
| Per group | Foam trays |
| Per group | Foil |
| Per group | Cardstock |
| 2 boxes | Paperclips |
| 1 box | Rubber bands |
| 4 boxes | Popsicle sticks |
| 1 pack of 10 per group | Balsa wood |
| Per group | Glue |
| 1 per group | Scissors |
| | Making tape |
| 1 per group | Ruler |
| 6 per group | Plastic cups |
| 5 pieces per group of 5 | string |

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