Lesson: **Will It Fly?**

Contributed by: Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder

Quick Look

Grade Level: 6 (5-7)
Time Required: 50 minutes
Lesson Dependency : None

Will it fly?

Summary

Students learn about kites and gliders and how these models can help in understanding the concept of flight. They learn about the long history of human experimentation with kites, the eventual achievement of flight with the invention of airplanes, and the pervasive impact of the airplane on the modern world (pros and cons). Then students move on to conduct the associated activity, during which teams design and build their own balsa wood glider models and experiment with different control surfaces, competing for distance and time. They apply their accumulated existing knowledge (from previous lessons and activities in this unit) about the four forces affecting flight and modifiable airplane components, and apply an engineering design methodology to develop sound gliders. To conclude, they reflect on and communicate the reasoning and results of their design modifications.

Engineering Connection

Orville and Wilbur Wright were inventors who might be considered early aeronautical engineers. When they designed their first airplane, they built balsa models and kites to test how well it would fly. Modern engineers do the same thing when designing airplanes. Engineers today also use computers to test aspects of their designs before they build the real thing. Doing this less expensive, easier and quicker since they can learn from their failures while using the small-size, inexpensive models instead of making costly mistakes using full-size prototype airplanes.

Learning Objectives

After this lesson, the students should be able to:

- Identify the four forces affecting flight.
- Describe the evolution of flight design through history.
- Explain why engineers build models before a final product.
- Give examples of how aircraft models can be modified to improve flight.

Introduction/Motivation

What are different types of aircraft? Today we are going to talk about kites and gliders.

How many of you have flown a kite before? What are the parts of the kite? (Answer: A basic kite has wings, a supporting structure, and a tail.) Is a kite made from light or heavy materials? (Answer: Usually light.) Does a heavy kite fly well in little wind? (Answer: No, you need a lot of wind to lift a heavy kite.) Do we all agree that it takes more wind to lift a heavy kite?

Why is that? (Look for answers that mention the need to overcome larger gravitational forces.) In what direction does gravity act? (Answer: Down.)

How many of you have seen fancy a kite that performs tricks? How about kites that have multi-levels? Can the person flying the kite move the kite around a lot? Who thinks a kite is just a toy? Well kites are not just toys! They can be a good tool for learning about airplanes, and especially about glider flight! A glider is any aircraft that flies without an engine.

Engineers can learn a lot about the flight patterns of a glider by first building a kite model of the glider. They can hold it by hand (if it is small enough to control) and observe its flight patterns when they vary any number of components: the wing shape and size, its position on the kite's body, the structure of the entire body of the kite, and various tail assemblies.

Early experimenters of flight built kites that resembled the glider or powered vehicle that s/he hoped to build later. Some of these kites were full-sized, resembling the glider or airplane they intended to fly later but using less-expensive materials. Sometimes experimenters placed weights on the kite to observe how specific weight being carried would change the flight pattern. The Wright Brothers were among those who built several kites of increasingly larger size before they built their gliders and powered aircraft. They used the kites and model gliders to experiment with wing warping and how much weight a kite or glider could carry before failing.

What can you learn from flying a kite? (Answer: You can learn how much wind needs to be present to overcome weight (lift); how wind affects the way the kite flies; how to control the kite's movement to not crash.) What can you learn from building a glider? (Answer: You can learn about flight patterns, how control surfaces affect flight, how much weight a design can hold, how much lift is created by wing shapes, etc.)

Not all engineering is well thought out the first time around. Sometimes, the best designs are accidental and emerge through a lot of experimentation. You are going to have an opportunity to use all of the information you have learned about aircraft flight to design and then redesign a balsa glider to increase its flight time and distance.

Lesson Background and Concepts for Teachers

So far in this unit, students have learned about the four forces affecting flight and variables involved in the engineering design of airplane models. This lesson leads them further through the thought processes behind airplane design and invites them look at the historical aspect of airplane design through the design of simple gliders. Students also have the opportunity to discuss some implications of historical and modern aircraft.

The social history of flight is pretty diverse. People have always looked to the heavens to determine the cycles of seasons, agriculture and life. Humans have dreamed about being able to fly to the heavens just as birds do. Mythological stories tell us about birds and other winged creatures that fly gods and their chariots through the sky and in and out of the clouds. Humans had the desire to emulate the gods by creating flying machines.

As knowledge of the universe grew, the connection between the heavens and mythological flight faded, and the desire to achieve flight remained. The ancient Chinese tried to sail through the air by attaching themselves to kites, one of the most significant inventions leading to flight. Other flight pioneers such as Leonardo da Vinci and the Wright brothers have made modern flight a reality. Throughout history and into modern space exploration, individuals have taken steps towards this dream, often with injuries and sometimes with fatal outcomes. Nevertheless, efforts continue and there is no turning back. Aviation has become part of the mindset of our world.

Air flight has changed society, from the development of small, crude airports servicing short flights to large, state-of-the-art terminals services quick, convenient travel through the air to far away destinations. You can see the influence of flight in literature, art, comics, music, movies and television. Space flight has always been a desire of humans as well, and space aviation is another large industry, dealing with both known *and* unknown realms.

Over thousands of years, thoughts of flight have been an underlying force in social development. From one point of view, flight has been very beneficial, bringing people closer together, allowing a new job market for people with flight-related talents, helped inspire creativity, and opened up a world of possibilities to exploration outside of Earth. However, some would argue that flight has been detrimental as well, as it has made warfare more intense, can be attributed to an increase in pollution, and is costly, taking money from other areas of need.

Vocabulary/Definitions

balsa: Light weight wood that is easily manipulated in making airplanes.

control variable: A standard that an experimental model is measured against.

design: A plan, sketch or outline made to serve as a guide or pattern.

distance: The amount of space between two things, objects or points.

glider: An aircraft similar to an airplane but without an engine.

kite: A light frame covered usually with paper or cloth, with a stabilizing tail, and designed to be flown in the air at the end of a long string.

Lesson Closure

(After completion of the associated activity, lead a class discussion about students' glider designs.) What modifications did you make to your glider? Did it make the glider work better? What could you do next time to make the glider perform even better? Do you think it is a good idea for engineers to design glider models before they build a real glider? Why or why not? (Encourage reasoning based on the knowledge gained from the previous lessons. Expect students to share their results and make connections.)

Assessment

Pre-Lesson Assessment

Brainstorming: As a class, develop a list of different aircraft or things that fly. The list might include toys, models, arrows, sports equipment, various types of airplanes, helicopters, drones, etc. Encourage wild ideas and discourage criticism of any ideas.

Post-Introduction Assessment

Question/Answer: Ask students questions and have them raise their hands to respond.

- What can you learn from flying a kite? (Possible answers: You can learn about how much wind needs to be present to overcome weight [lift]; how wind affects the way the kite flies; how to control the kite's movement.)
- What can you learn from building a glider? (Possible answers: You can learn about flight patterns, how control surfaces affect flight, how much weight a design can hold, how much lift is created by wing shapes, etc.)
- True or False: All of the best engineering designs come from well-thought-out plans. (Answer: False, it is rare that a well-conceived and polished design idea is the first idea. Sometimes, the best designs are accidental ideas and/or improvements that occur during experimentation and turn out to be better than the original design idea.)
- Review the concepts from the previous lessons that can affect flight. What is the affect of weight on flight? What do control surfaces have to do with how an airplane flies? Are bigger wings better or worse for a glider?

Lesson Summary Assessment

Venn Diagram: Have students create a Venn diagram to compare and contrast the different types of aircraft that have been discussed.

- Have students draw three overlapping circles. Label one circle with kite, the second circle with glider and the last circle with airplane. Direct students to list all of the observations the three types of aircraft have in common in the overlapping sections and all observations of what is different for each aircraft in the outside circle sections.

Class Debate: Divide the class into two groups. Have one group argue for (agree with) the topic and one group talk against (disagree with) the topic. Give the groups a few minutes to come up with their arguments before the class debate.

- Topic: The flying machine (aircraft) has changed society for the better. (As examples: pro-aircraft students might discuss transportation advances and globalization, and con-aircraft students might discuss pollution consequences, high carbon footprint and/or increased warfare capabilities.)

Cartoon Character: Cartoon characters such as Bugs Bunny have often been sent into flight missions to escape a situation. Create your own cartoon sketch of a character in flight. Your character could be in a glider or airplane, or maybe hanging from a kite. Make sure to label one of the four forces (drag, lift, weight or thrust) acting on the character and have your character saying something about how the force is affecting them.

Lesson Extension Activities

Assign students to research and report on other early models of aircraft and the engineers/inventors who developed them.

Have students research kite-flying tricks. How can the tricks accomplished by different kites be explained in terms of the four forces affecting flight?

Suggest that students redesign their gliders for other factors, such as carrying cargo. Whose glider can carry the most pennies and still fly a distance?

Additional Multimedia Support

Turner Toys & Hobbies: Smart toys for smart kids. http://turnertoys.om/index.php?p=404

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Supporting Program

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Hands-on Activity: **Balsa Glider Competition**

Contributed by: Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder

Quick Look

Grade Level: 6 (5-7)
Time Required: 50 minutes
Expendable Cost/Grp : US $5.00
Group Size: 4
Activity Dependency : None

Summary

Students act as if they are engineers designing gliders, aiming to improve the flight distance and time in the air. First, they determine the controls—the average distance traveled and time aloft for their basic model balsa wood gliders. Then they modify the wings, testing and reworking their altered designs to achieve improvements in distance and time. Using a design procedure whereby one variable is changed and all the others are kept constant, they determine how each modification affects the flight. They make measurements and analyze the class data. This activity brings together students' knowledge of engineering and airplanes, applying what they have previously learned about lift, weight, thrust and drag to glider models, as well as their understanding of the control surfaces—elevator, rudder and aileron—that control pitch, yaw, and roll, respectively.

Engineering Connection

When working with models, engineers test, make changes, test again, make more changes, and so on until they have a successful design. It is important that engineers use scientific methods in their testing, so they know what to change about the aircraft to fix any problems. Using this process, engineers make improvements and work out the "bugs" so they end up with well-designed aircraft. Also, by using small-size airplane models, the process is less expensive than testing on full-size airplanes.

Learning Objectives

After this activity, students should be able to:

- Describe the steps of the engineering design process
- Compare a glider model with actual glider flight.
- Use variables to conduct an experiment.
- Use glider models to solve a problem and communicate their results.

Materials List

Each group needs:

- balsa wood glider kit, one per student; available at hobby and craft stores
- Balsa Glider Competition Worksheet, one per student
- sandpaper
- glue

- tape
- scissors, coping saw blades, or razor blades
- safety glasses

For the entire class to share:

- stopwatch
- 50-foot cloth measuring tape 50 feet; see if can borrow from the gym teacher or custodian

Introduction/Motivation

Building and flying balsa airplane models is an excellent way to learn about airplane construction and flight. Balsa models are not just toys: engineers also create models of their designs before building the real, full-sized craft or product. Building models was an early method used by the pioneers of aviation. Early designers did not just begin by building flying machines and racing about in them—that would have been far too dangerous. These early inventors and engineers—such as the Wright Brothers—began with building model kites and gliders to learn about flight patterns. At a smaller scale, they played with wing shapes and sizes to see how much kites and gliders could carry. They once created a model kite that could carry a 10-year-old boy!

What is the difference between a glider and an airplane? (Listen to student ideas.) A glider is any aircraft that flies without an engine. Gliders can have all the same parts as an airplane, but use the wind—instead of fuel—for power. How many of you have ever made a glider out of balsa wood? (If possible, show an example of the models they will be making or show them what the balsa wood looks and feels like.) What makes balsa a good material for glider model design? (Possible answers: It is very light, easy to cut and alter; and inexpensive.)

Today, we are going to act as if we are engineers who are designing gliders that can either travel a long distance or stay airborne for a long time. To do this, we are going to look at what the *normal* time (or, *control time*) of a balsa glider's ability to travel a distance and to stay aloft. From the information we have learned on the four forces of flight (Who can name them? Answer: lift, weight, thrust and drag), we are going to modify the wings of our glider. This is called the *independent variable* or the variable (part) of the glider that we will be changing as engineers.

(As necessary, review with the class the four forces that act on airplanes—lift, weight, thrust and drag. Also, review the control surfaces—elevator, rudder and aileron—and what they control—pitch, yaw, and roll, respectively.)

Procedure

Before the Lesson

- Obtain enough balsa wood plane kits so you have one per student, plus a few extras
- Make copies of the Balsa Glider Competition Worksheet, one per student.
- Make an overhead transparency of the Class Data Blank Table Overhead.

With the Students

1. Organize the class into groups of four students each.
2. **Determine baseline controls:** To begin, have the class establish the controls: the average distance traveled and average time aloft for a basic glider.

- Have each team select a "representative" to assemble one glider to become the "basic" glider used for control testing.
- Have half of the teams complete a distance test with the basic gliders: have team representatives stand in a central location, and throw the gliders. Measure how far each glider traveled and record in the class data table, then average the distances. This is the *distance control*.
- Repeat this process to find the average time aloft with the other half of the teams and using the stopwatch. Record in the class data table the time aloft for each team and average the times. This is the *time control*.
- Note: If time allows, have each team representative throw his/her glider one at a time so that all students can observe the flight of the gliders. However, regardless of time, unless several stopwatches and adults are available

to record the gliders' time aloft, students will have to do this step one at a time.

3. **Design:** Working in their groups, have team members propose wing shapes that they would like to design to increase either the distance or time aloft of their gliders. Emphasize the benefits of teamwork in engineering: listen to everyone's ideas and make sure everyone participates. To help with this, have each team member use the space provided on the worksheet to draw a wing shape for each *(control) variable*, and write a sentence or two explaining why s/he decided on that particular shape for each variable. The new wing shapes are the *independent variables*. Then have team members share their ideas, discuss the pros and cons of each idea and come to agreement (or vote, if necessary) on the two shapes that they would like to try out on their gliders.

3. **Build:** Within the groups, have pairs work together to build the modified gliders.

- At this point, each group of four should have three glider kits left, since one was used to build the "basic" test glider.
- Students may decide to use the final glider kit for parts to supplement the other gliders or save the kit in case any mistakes are made.
- Remind them that mistakes do happen during the engineering process and we can learn from our failures.
- Now, it is time to build!
- Give teams enough time to trial run their designs and rework them as necessary.

3. **Test:** When ready, have each team test their gliders. Have the student pairs within each team fly their glider three times and record the distance traveled and time aloft for each flight. (These three times are their trials.) The new results are the *dependant variables*. Have the student pairs average their results.

3. **Analysis:** When all teams have finished their trials, compile all team data into the class data table and examine the results:

- *Average all of the class results:* Did the changes the teams made to their wing shapes improve the flying distance and time aloft compared to the basic glider?
- *Determine the most common (mode) flying time and distance traveled for the class.* If there is not a single mode, did most of the planes travel close to the same distance/time?
- *Determine the longest distance traveled and time aloft for the entire class.* Why do those specific gliders have the best overall results?

Attachments

Balsa Glider Competition Worksheet (pdf)
Class Data Blank Table Overhead (pdf)

Safety Issues

If students are cutting the balsa with saws or razor blades, set up a cutting station where all of the cutting is performed so that you can keep an eye on any safety risks.

Require students to wear safety glasses when cutting the wood.

Troubleshooting Tips

Make sure students know how to use the materials and tools. To ensure safety, model the correct use of each tool.

If weather permits, conduct the flights outside and spread out so students are not hit with flying gliders and do not accidentally step on others' gliders.

Assessment

Pre-Activity Assessment

Review Discussion: Review with the class the four forces that act on airplanes—lift, weight, thrust, and drag. Also review the control surfaces—elevator, rudder and aileron—and what they control—pitch, yaw and roll, respectively. Show a picture of an airplane or draw one on the board to point out the forces and control surfaces.

Activity-Embedded Assessment

Worksheet/Pairs Check: Have students work individually or in pairs on the Balsa Glider Competition Worksheet. Have students who work in pairs check each other's answers.

- Have students use the space provided in the worksheet to sketch the wing shape they would like to use.
- Have students record the results of their glider trials on the worksheet chart.

Post-Activity Assessment

Discussion: Lead a discussion on the distance the gliders flew. Start out by asking students if their predictions (on the worksheet) were correct. Then compare which wing designs worked and which ones did not and why.

Figure Drawing/Engineering Design: Have student apply what they learned about which wing designs worked and which ones did not to design new gliders on paper. Have them draw the four forces of flight affecting their glider and how their wing design is developed with those forces in mind.

Activity Extensions

Drawing Conclusions: Have students record other attributes of their planes such as the weight, the wing area, the use of control surfaces, and the plane length. Have them draw conclusions as to how these variables affect flight attributes, such as flight distance, flight time and aircraft stability.

Graphing: Have students or teams create bar graphs of the shape of the wing vs. distance or time. The x-axis could represent the control airplane, wing shape #1, and wing shape #2. Have them explain the patterns of their graphs to the rest of the class.

Back to the Drawing Board! Have teams circle back to earlier steps of the engineering design process to come up with improvements to their original designs. Have them modify other aspects of the designs such as wing length or have them put control surfaces on the wings. Suggest they use any of the extra balsa wood for parts.

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