

Why Are Plane Designs So Different?



Welcome to NSTA's Daily Do

Teachers and families across the country are facing a new reality of providing opportunities for students to *do* science through distance and home learning. The **Daily Do** is one of the ways NSTA is supporting teachers and families with this endeavor. Each weekday, NSTA will share a sensemaking task teachers and families can use to engage their students in authentic, relevant science learning. We encourage families to make time for family science learning (science is a social process!) and are dedicated to helping students and their families find balance between learning science and the day-to-day responsibilities they have to stay healthy and safe.

What is Sensemaking?

Sensemaking is actively trying to figure out how the world works (science) or how to design solutions to problems (engineering). Students *do* science and engineering through the <u>science</u> <u>and engineering practices</u>. Engaging in these practices necessitates students be part of a learning community to be able to share ideas, evaluate competing ideas, give and receive critique, and reach consensus. Whether this community of learners is made up of classmates or family members, students and adults build and refine science and engineering knowledge together.



Materials

Items: (For Each Group) Pen/Pencil, Letter-sized paper (8 1/2 in x 11 in), 2-4 sheets per group Stopwatch, Meter Stick or Tape Measure (you can also use steps to measure distance), Target

Video: YouTube – Awesome F-22 Raptor Falls/freefall from sky in full control 4K

Video: YouTube – US Awesome Sounding C-5B Galaxy. "With GE TF-39 Engines "

Video: YouTube – World War Squared – Episode 1

Video: YouTube – Aerospace Engineers -- What is it?

Video: YouTube – Consider a Career in Business Aviation

Handout: Catch a Glider

Optional Handout: Science and Engineering Practices – Developed by NSTA using information from Appendix F of the Next Generation Science Standards

Collection of Resources: Direct links to all videos, articles, handout materials, and other resources – <u>https://bit.ly/DD-05-15-2020</u>

National Paper Airplane Day!

National Paper Airplane Day is celebrated every year on May 26. In honor of the day, we're refeaturing the Why Are Plane Designs So Different? Daily Do. Share your paper airplanes with us on Twitter - @NSTA #DailyDo - and tell us how they flew!

Introduction

Structure and function is an important relationship in both science and engineering. Structures can be designed to serve particular functions by taking into account the properties of different materials. We can find structure-and-function relationships in both living and human-designed things at many scales.

In today's task, *Why are plane designs so different?*, students and their families engage in science and engineering practices and use the thinking tool of structure and function and patterns to figure out how the shapes of structures help determine a plane's function.



Let's Take Off!

Ask students, "Have you ever thought about why all planes aren't the same? There are two planes I'm thinking about in particular, a F-22 Raptor and a C5-B Galaxy."

Tell students you have a <u>video of a F-22 Raptor</u> you want to share. Ask them to make observations and record them in their science notebook or blank paper. You might give them time to make observations before starting the video.

Next, tell students you have a video of <u>C-5B Galaxy</u> to share. Ask them to create a table titled *Similarities and Differences between a F-22 Raptor and C-5B Galaxy;* the table should have two columns, one labeled *Similarities* and the other labeled *Differences*. Ask students to note similarities and differences between the two planes as they watch the video.

Alternatively: Ask students to make and record observations of the C-5B Galaxy as they watch the video. Then give them a few minutes to use their observations of the two planes to create the *Similarities and Differences* table.

Assign students to small groups. Tell students they will use the Talking Stick protocol to make a claim about the *function* of one of the two planes (or both planes if students have two turns to share). Remind students to support their ideas with relevant evidence from their *Similarities and Differences* data.

Next, tell groups to choose one plane and be ready to share with the whole class:

- the group's claim about the *function* of the plane, and
- evidence that supports the claim.

Talking Sticks

- 1. Each person puts his/her pen on table.
- 2. Take turns commenting. Pick up your pen when it is your turn. Others are silent (listening!)



- 3. After commenting, keep holding your pen. Replace it only after all group members have had a turn. Then you may go again.
- After everyone has commented (all pens are picked up) put them back down.
 Repeat. Note: Everyone comments! If you have nothing new to add, you may comment on what someone else has said.

As each group shares, look for opportunities to ask, "Why does the shape of _____ matter for its function? What other properties of the structure might allow it to have certain behaviors?"



For example, if students bring up the body of the F-22 Raptor as evidence of its function, ask why the shape of the body matters for its function (aerodynamic, makes it move fast; large surface area, increases lift so it can fly high/far) and what other properties of the body allow it to fly fast/high/far (rigid, light-weight, etc.).

After all groups have had an opportunity to share, ask, "What are some ways we could test our initial thinking?" Students might respond:

- Research the two planes
- Make model planes and fly them
- Use a flight simulator to fly different planes

Say to students, "We have material available to make model planes. Does it make sense to start there?"

Testing Two Airplane Designs

Tell students you have directions for paper airplanes that are similar to the F-22 Raptor and C5-B Galaxy.

Ask student, "What type of data should we collect to test our ideas about the *functions* of the two planes we based on their *structures*?" Students might suggest:

- distance
- speed
- time in the air
- accuracy (ability to hit a target)

Set up testing stations around the room or outdoor area if it's not too windy. Tell students each group will be assigned data to collect (or you might allow groups to choose). *Ideally, at least two groups will collect the same data.* Ask the groups to plan their investigation and to identify how they will keep their testing fair. Then, ask groups collecting the same type of data to meet to discuss their plan for investigation and fair-test list. Allow groups to make changes to their plans/lists based on feedback provided by another group.

Students' fair-test lists might include:

- same student throws the planes/holds the plane the same
- same force is used to fly the plane
- distance is measured from starting point (tip of throwing student's foot, for example) to first point of contact with the ground.



- planes are "uncrinkled" before each flight
- creases are the same on both planes (creased using the same method)

Ask students to create data tables including title and labels. This is a good opportunity to discuss the number of trials and the circumstances that might require students to "redo" a trial (e.g., airplane swooped away by wind, airplane strikes a student). You might consider asking students to include a space in their tables for observations if you plan to have students record the flights of their paper airplanes.

Now it's time to make the paper airplanes!

Materials (for each group)

- Letter-sized paper (8 1/2 in x 11 in), 2-4 sheets per group
- Stopwatch
- Meter stick or tape measure (you can also use steps to measure distance)
- Target

Note: You might choose to put materials at the stations instead of distributing to groups.

Tell students the directions for folding the paper airplanes are in the <u>World War</u> <u>Squared</u> video. You can play the video at slower speed - Settings > Playback Speed > 0.75 (or 0.5).

- 0:00 2:55 Hot Dog plane (includes brief introduction to National World War II Museum)
- 2:55 5:30 **Hamburger** plane

Ask students to check in with you (show you their paper airplanes) before they begin their investigations.

Allow student groups to conduct their investigations.

Analyzing Data: Forces of Flight

Create a space where students can report the (average) data they collected to the class. You might use poster paper, a virtual white board like Jamboard. or shared Google doc/sheet. (If more than one group collected the same type of data, put both results in the same space on the table.) Make sure it is possible for students to see all the data collected by the class.



Ask students, "What patterns do you observe in the data presented in our class table?" Give students time to work independently (Alone Zone) and ask them to record ideas in their science notebook or blank paper.

Then, ask the class to share the patterns they observed with a partner.

Next, ask students to share a pattern they observed or their partner observed with the class. You might record and put check-marks next to patterns that students have in common (add a check mark each time the same pattern is shared).

Ask students, "How might the *structures* of these planes explain their *functions*? That is, how might the different *structures* of the plane explain the patterns we observed in our data?" Ask students to discuss this question in their groups. Don't have the groups share their ideas yet.

Go back to the video and play from 5:30 to 7:05. Draw a plane for the class. Ask students to share the forces acting on a plane (lift, gravity, thrust, drag). Ask students, "How should I represent the force? (use arrows) How could I represent the size of the force? (thickness of arrow, darkness of drawn arrow, length of arrow)"

Consider drawing the forces all the same size an in opposite directions (thrust-drag/lift-gravity) and asking, "What do predict is the motion of the plane in my model? (hovering in air, not moving)" You might change the forces acting on your model and again ask students to predict the motion of the plane.

Now, ask students to turn back to their groups and continue their discussion about how the different *structures* of the plane explain the patterns observed in the class data and to consider the forces acting on the plane. You might hear students talk about the relationships between:

- surface area of structure and lift
- weight of structure and lift
- structure shape and drag

Ask students, "Why would engineers design a cylinder-shaped structure (C5-B Galaxy) vs a flattened triangle-shaped structure (F-22 Raptor) considering drag? (the C5-B Galaxy needs to carry cargo/people and cylinder shape creates space)"

Point out to students that while plane *structure* determines the *function*, the design is ultimately based on a *need* or *want*.



Redesign Planes!

Let students know they can use the engineering design process (outlined below) to choose one plane (per group) and redesign it to fly further, faster, more accurately or stay in the air longer. They might also choose to redesign a plane to carry a heavier load.

Share constraints for the airplane designs with your students. Constraints might include

- number of sheets of paper used to build body of plane
- materials that can be used to add-to/change the design of the plane
- equipment available to build the plane (scissors, tape, glue)
- time



Assign students into group based on their design goals (put students together who want improve the distance the plane travels, for example). Ask students to determine (1) the criteria for success for their designs and (2) how they will test their designs. Remind students to use the class data to help them determine success criteria and to refer to the fair-test list they generated when coming up with their testing procedure.

Give students an opportunity to individually brainstorm ideas for their design. As you walk around the room, ask questions like, "How do you think this *structure* (point to structure) will improve the *function* of distance/speed/accuracy/load? How will changing this *structure* affect the lift/drag/weight?"

Ask students to share their ideas with their group and then come to consensus on group plan. Make sure each group has criteria for success, a testing procedure and a complete design before allowing them to build their plane.

After students have created, tested and improved their designs, bring the class back together. Ask each group to show their final design to the class and answer these questions (which include teacher notes):

• Was your design successful? How well it meets the criteria for success.



- What is one thing you really like about your design? Even if the design was unsuccessful, students can identify a design feature that they like/are proud of that might become the basis of an improved design.
- How would you improve your design if you had more time or different materials? *Engineers are always seeking to improve designs even when the design is successful.*

You might ask students to share how the *structures* of their planes affected lift, drag, and weight of their planes.

Note: Check out the *How can properties help solve problems? Daily Do* for brainstorm, group plan, and reflection scaffolds.

The Engineering Design Process (EDP) comes in many forms. Engineers enter the EDP to create a new technology - or improve an existing one - to meet a need or want. Engineers on the job may start at any step, depending on the needs of a particular project.

Science in History

To explore a real world science and history connection, ask you students to read <u>Catch a</u> <u>Glider</u> (or read the story together).

You might ask students to discuss how the glider might have been improved to better rescue the stranded service men and women.

Explore STEM Careers in Aviation!

Share with students, "Now that you figured out the ways a plane's design effects its function, explore what it takes to enter exciting STEM careers in aviation!"

Aerospace Engineers - What is it?

Consider a Career in Business Aviation

STEM Career Awareness is an important part of educating and preparing our students for the future workforce.

NSTA Collection of Resources for Today's Daily Do

NSTA has created a <u>How does the Design of a Plane Determine how it Functions?</u> collection of <u>resources</u> to support teachers and families using this task. If you're an NSTA member, you can add this collection to your library by clicking ADD TO MY LIBRARY located near the top of the page (at right in the blue box).



Acknowledgement

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CATCH A GLIDER



Paratroopers entering a C-47 on training at Fort Benning, GA, June 1944. (*The National WWII Museum, 2011.065.1293*)

In spring 1945, the outcome of the war was starting to look a little better for the Allied powers. Germany had surrendered on May 8, and after some very tough battles in the Pacific, the Allies were getting closer and closer to the mainland of Japan.

New Guinea was taken back from Japan a year earlier. An American base at Hollandia (now called Jayapura) had a good port and landing strip. Hollandia had been a Japanese base, and the Americans now used it as part of the supply route for the continuing battle in the Philippines.

The war had been going on for a long time. Even office workers and supply clerks far from the battlefield worked six or seven days a week. Officers tried to keep up the morale of their workers and soldiers by planning enjoyable events.

On May 13, 1945, Lieutenant John McCollum took a group of 19 people on what he hoped



1940's map of New Guinea. (Courtesy of the United States Army)

would be a pleasurable sight-seeing flight. To the south of Hollandia were mountains that reached an altitude of over 5,000 feet. Hidden within those mountains was a high valley called Baliem.

Years earlier, an explorer named Richard Archbold was looking for new animals in New Guinea and discovered this 20km-by-80km valley. About 200,000 native people lived in small villages in this valley where they domesticated animals and tended to large gardens.

After the American forces took New Guinea from the Japanese, they began mapping the island as they flew over the island to Australia. When the valley was rediscovered, news reporters gave the valley a more fanciful name—Shangri-La—after a fictional place in a novel called *Lost Horizon*. People who lived in the valley were the subjects of wild stories.

Lieutenant McCollum thought it would be fun to fly some of his people over the valley so that they could see this strange place and bring back more stories about it. With four other crewmen he loaded his passengers, who included some WACs (Women's Army Corps), into a C-47 (a large cargo plane) and headed for the valley.

The pilot was inexperienced at flying in mountains. He lost control in strong winds, and the plane crashed into the side of a mountain at the edge of the valley. Only five people survived the crash and two of those five died of their injuries soon after the crash. Corporal Margaret Hastings, Sergeant Kenneth Decker, and Lieutenant McCollom were injured but left the crash site for the valley floor to find help.



Glider troops about to board in Italy, August 1944. (The National WWII Museum, 2002.337.825)

When the plane did not return, search planes were sent to look for them. The valley was so large that it took four days to locate the survivors. Two medical paratroopers and 10 other paratroopers were dropped nearby to help the three survivors. Other planes dropped food and tents and other supplies.

The area around the valley was unexplored and hundreds of miles from the base in Hollandia. It was possible that Japanese troops were still occupying the high mountains and dense jungles. To make matters worse, the uneven ground, which was densely covered with plants, could not be cleared to make a landing strip. It took six weeks to devise a rescue plan to get them out of the valley safely.

The final plan involved another C-47 and a glider. The glider, built of aluminum and balsa plywood frames covered with canvas, had a simple steering system. The C-47 carried the glider to the valley, and then a glider pilot landed the light craft near the survivors' camp site. The survivors and paratroopers were loaded into the glider. Then came the exciting part.

The C-47 returned with a cable and latched onto a hook on the glider. After being pulled across the rugged valley floor, the glider lifted into the air. A few more passes were needed to successfully hook the glider, and it took several trips to get all of the survivors, medics, and paratroopers out, but ingenuity and perseverance eventually carried the day.

How would the design of a cargo and passenger plane be different from a glider?

Why was the glider made of flimsy material like balsa plywood and canvas?

What was daring about the rescue attempt?