Lesson 5: Heavier than Air—Planes and RFPs

Students will learn the role biomimicry plays in aerospace design and iteration. They will also work as teams to complete a mock request for proposal (RFP). Working in designated roles will expose students to the structure of engineering projects while teaching them how to navigate specific instructions.

Learning Objectives

Students will

- Learn the basics of a request for proposal process and how multiple roles are necessary for the successful execution of projects
- Construct a paper airplane and attempt at least one flight
- Learn the benefits and challenges of having defined individual roles
- Develop an understanding that design can be inspired and influenced by many sources

Materials

- 8 ½" X 11" paper (each group should receive one piece of paper at a time, allowing for them to iterate on designs after they have completed a previous design)
- Timer
- Computers and an internet connection, if you elect to complete the additional online activity

Time

2 hours

If you choose to extend this lesson, consider changing the parameters of the RFP and assigning students to different groups with new roles.

WELCOME AND CHECK-IN (10 MINUTES)

This is a good time to check in with students to see how much they have retained from previous lessons. Ask them questions about what they have learned so far.

- What creates thrust in an airplane engine?
- Can you identify a difference between a propeller and jet engine?
- How can engineers make a plane more aerodynamic?
- What do you know about Bernoulli's principle and Newton's third law?

Birds fly through minimizing the drag on their wings. They do this by changing the shape of their wings while they are in flight.

You can show a short clip of birds in flight with their wings moving in slow motion. This imagery will show students how wings shift, rotate, and change throughout different points in a bird's flight path.

> A new technology being developed by university researchers in Wales, Great Britain, is a shape-morphing wing flap that will replace conventional flaps, which cause drag and noise. When controlled by a tailored motor, the new flap is able to bend and twist at the same time, creating an adjustable, three-dimensional, curved shape.

The idea of aircraft parts morphing shape to maintain optimal performance stems from our understanding of how animals fly. For example, birds will minimize drag by changing the shape of their wings during flight. Applying this knowledge to engineering and trying to model planes after birds is known as biomimicry. The development of this new technology allows planes to mimic the technique of birds.

With the advancements being made in strong lightweight plastics, radical electric planes may be in the not-so-distant future.

PART I: THE CONSTRUCTION PROCESS (10 MINUTES)

Consider showing students current exploratory planes or drafts of future designs. Aeronautical engineers are continually working to improve efficiency and push the bounds of flight. Some drones are now using biomimicry to mimic the maneuverability and flexibility of bats.

Airplanes are rather complicated. Many, many engineers and technicians work together to design, build, and test airplanes. But aerospace doesn't actually begin with building airplanes. It begins with an idea. What kind of idea? Maybe something new—faster, lighter, et cetera. Maybe something to be improved upon—less drag, sleeker design, new materials. How can we make this idea a reality?

First, you need to recruit and build your team. Whom do you draft?

There are individuals who work together to bring a plane to life. Everyone has to collaborate to stay on target and complete the project.

Designers, engineers, and researchers understand physics, math, and chemistry. They use the scientific method to gain further understanding, to find the possibilities, and to advance systems that we may already use. They figure out how to use propulsion and aerodynamics while deciding which materials to use to build a product. Eventually that specific product is built, and users will have the chance to purchase it.

Most ideas take years and many, many iterations before they are ready for production and in the hands of users. All aerospace engineers exhibit patience, a collaborative spirit, and an inquisitive mind during the ideation, design, building, and testing processes.

The students will work in groups in which they each have a designated role. It is important for them to understand that everyone has equally important jobs in the process, even if they do not get assigned their favorite role. You may find it helpful to show students examples of teams that work together in systems. Show students process flow charts explaining the workflow of aerospace programs if possible.

You may want to provide students with a more concrete example. Consider giving them a macro view of the process of purchasing a new phone. First, a company received an RFP for a new phone, then they had to work through all of the stages of design, iteration, and redesign. After selecting a design they had to decide who could provide the construction materials and labor at the cheapest price. They'd test the product and

make sure it matched what the company asked for. As a final step the company would have to pay to have phones shipped to locations all across the world. All of this happened long before the phones arrived on shelves and were available for purchase. The RFP was the first step in the process.

PART II: RFP FOR A PAPER AIRPLANE (60 MINUTES)

> I would like each of you to make a paper airplane. Your goal is to create a plane that will stay in the air for a long time.

Pick a student to hand out one piece of paper to each person. Give students 2–3 minutes to make their airplanes. You can allow students to fly their planes once, but instruct them to be careful of colliding with others' planes. Have students retrieve their planes from where they land in the classroom.

After each student has made and flown one plane, explain the following:

> Now you each have a basic understanding of making your own paper airplane, but as we have already discussed, it takes many people to build an airplane. Engineers make up a few members of the team for airplane construction.
>
> Here is a request for a proposal for you.

Here you will need to show an RFP to students to illustrate the necessary directives and how specific they need to be before a project can begin. Your RFP should include the following constraints

- Construction of a paper airplane, capable of single-handed launch
- Should be constructed from one 8 ½" X 11" sheet of paper
- The paper airplane that stays in the air the longest (not distance traveled) will win.

Students may cut and paste the piece of paper if they want. If you decide to let students construct another plane after the first launch, you can increase or decrease the amount of paper or change the parameters of the RFP.

> Any questions on the RFP? Do you understand what the requirements and restrictions are so far? You are going to be put into a design team of four people. This design team is a bit tricky.

Consider giving each group a different colored paper so they can easily identity each other's planes during the competition

If students are prone to cliques, group them before class so they have an opportunity to work with new people. Once in groups, have the students count themselves off from 1 to 4. Assign one role to each number (all 1s will be managers, et cetera).

> There are four jobs: the manager, the designer, the manufacturer, and the pilot. Each job has different responsibilities, and every position requires different abilities. Managers are usually good at encouraging their employees to stay on track but also at critiquing work without insulting them.

Post or project all of the job descriptions and corresponding numbers at the front of the room so students remember what their roles are and what components of the project they should or should not be handling.

Communication and following directions are imperative to this exercise. You want students to learn the importance of teamwork and collaboration. Reiterate to students that they must follow the instructions of their manager and not complete any task outside of their job description.

Manager Tasks

- Makes sure that your team stays on task and delivers on time (you have 15 minutes to build your airplane)
- Is in charge of settling any issues that may come up between team members
- Is the only person who can communicate questions to the teacher
- Is responsible for the project
- Does not design
- Does not build
- Does not fly

So what do you think of this job? In many companies this is a higher-paid position. Managers are responsible for the successful delivery of the project. If anything goes wrong, it is their fault! If the product is not completed on time, or if it fails, the manager is considered responsible.

Designer Tasks

- Takes instructions from the manager
- Designs the plane and tells the manufacturer how to design to their specifications
- Improves or changes design based on feedback from the pilot
- Does not build
- Does not fly

The designer must understand the requirements as outlined by the manager. They actually design and redesign the product as needed. How do you think they do this when they don't actually get to build the product? Can you begin to understand how important it is to be able to communicate? An engineer must be able to explain their thoughts verbally, in writing, using diagrams, graphs, charts, and equations. Engineers need a variety of skills.

Manufacturer Tasks

- Takes instructions from the manager
- Receives input from the designer to build the plane
- Provides the pilot with the built aircraft
- Modifies aircraft as needed based off feedback from the designer and pilot
- Does not design
- Does not fly

Imagine if a designer doesn't actually understand how a product is put together. How can they then get it manufactured? What if the manager doesn't understand the design? Yes, there are different skills needed for each job, but there are also some basic skills that everyone needs! The manufacturers only do what they are told to do. They may have ideas or concerns, but they have to share them with the designer. The manufacturer may not fix or change the airplane without first getting the approval of the designer.

Pilot Tasks

- Takes instructions from the manager
- Test flies the aircraft
- Tells the rest of the team how the aircraft performed
- Does not alter the plane
- Is the pilot for the final competition

> We finally have a product; now we test it. If the pilot doesn't understand what to do, they must ask for guidance. The manager also better make sure the pilot understands what to do. If the product is ruined during a test because of pilot error, it will be the manager who must defend the result.
>
> Go build!

Make sure that everyone understands their roles before releasing them for the activity. Give students 15 minutes to strategize, build, and fly their airplanes. Consider giving them 5-minute countdowns to keep them on task and create excitement through working under pressure.

After time is up, tell the class to send their pilots to the front of the room for the competition. Have only one pilot launch at a time, and record how long each plane is in flight. If you want to incentivize the challenge you can have small prizes for each person on the winning team.

Think about what motivates your students and what they would like to receive as a reward. If you choose to have the prize be a larger incentive, announce what it is after students have gotten into their work groups.

PART III: ONLINE ACTIVITY (OPTIONAL, 30 MINUTES)

If your group has access to computers (1 for each pair of students), they may find it fun to explore an online flight simulation game. There are several games that take students through the building process of the Wright brothers or allow students to test fly aircraft that they create. We recommend starting with the National Air and Space Museum resources. If you decide to include an online activity for students, play it yourself first to make sure that it is appropriate for your class.

> Let's go back to the Wright brothers. You just experienced what it was like to be part of a design team. Remember, a design team uses what researchers have discovered. The Wright brothers played all of these roles between the two of them. Very little was known about wings, propellers, or engines at the time. They ran experiments. They were the research team. They were the design team. They were the manufacturers and pilots! To help you get a feeling for what that was like, the National Air and Space Museum has created a simulation program. You will work in pairs to explore the Wright workshop.

PART IV: FEMALE STEMINISTS (10 MINUTES)

Girls are underrepresented in all STEM fields, so it is important to give girls a chance to speak in front of the class and step into leadership roles throughout the coursework. Since girls have now worked within definitive roles as part of a collaborative team it will be helpful to show them how what they just did happens in actual STEM careers. The students can watch a video of female scientists to showcase real role models for

them (keep diversity in mind in the resources you choose—you want to inspire all girls to see themselves in STEM careers).

Guiding Discussion Questions

- What was a challenge of working in one role and not being able to do anything outside of your job description? What was successful about this system?
- Why do you think the RFP process is necessary when building products?
- What did you learn through your specific role on your team?
- What is biomimicry?