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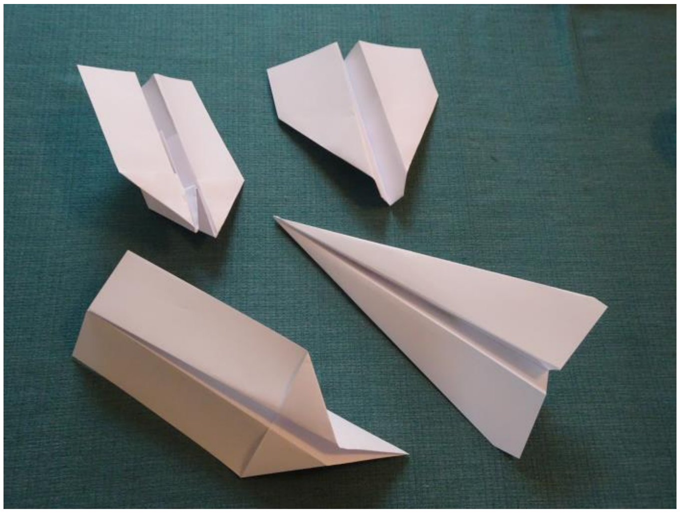
SHAESTA WAIZ

Optimizing Paper Airplanes to Become a Great Engineer

STEM Lesson Plan for Grades 6-8

Helping all students, especially girls, to be interested in engineering as a possible future career can be challenging. Research suggests that role models are important for helping students to see themselves in jobs where they have been underrepresented. In addition, having challenging and fun engineering experiences help students to want to become engineers.



Many engineering projects are focused on competitions, but that isn't the essence of engineering. The cycle of determining a problem, identifying what's needed to solve the problem, trying and testing possible solutions, and optimizing and iterating to find an acceptable solution is what makes an engineering project.

NGSS Standards
ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions
ETS1.C: Optimizing the Design Solution
PEMS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
DCI PS3.B: Conservation of Energy and Energy Transfer
DCI PS3.C: Relationship Between Energy and Forces

In this lesson plan, students will watch a video where Shaesta Waiz explains how she became a successful engineer. After figuring out what she says are some key factors to being a great engineer, they will embark on an engineering project where they will try to make and improve a paper airplane. Finally, they will look back at their work habits to determine how closely they matched skills that the engineer suggested were important.

Part I: Watching the Shaesta Waiz Video

Before the students watch the video, the teacher should explain that in this video an engineer will explain what makes her a successful engineer. The teacher should ask students to record what personality traits, desires, and behaviors are important to becoming an engineer.

For younger students, you may need to use sentence starters like

Shaesta Waiz said that she had to overcome the obstacles of _________
Shaesta Waiz said that she wants to _______

The video has on-screen icons that will help students when she is saying key components of her success. For some students, pausing the video at those moments will help them better record what is going on.

In small groups have the students summarize what they saw and then make sure that the entire class has all of the points. While they may have more than these, they should at least note:

- Shaesta Waiz is an engineer because she wants to help people.
- Shaesta Waiz is an engineer because it gives her a chance to be creative.
- Shaesta Waiz mentors and helps others.

Making a Great Engineer Checklist

Students now should now make a checklist of things for themselves to do if they want to be a good engineer. Then when they do something on the checklist, they should mark it off. For example,

Activity	
I helped someone	~~IIII~~ I
I didn’t give up when something didn’t go the way I planned	~~IIII~~ III

Students will use this checklist several times in the following projects. Don’t assign points or give too much praise, otherwise students will just game the system. We just want them noting when they are doing something a good engineer does, helping them to internalize that they can be an engineer. Alternatively, you can make it the task of one of the members of the group to note when their groupmates are being good engineers.

Part II: Engineering Cycle

Each group is given one of four airplane designs and is asked to make it carefully. Each group demonstrates its plane to the class. As a room, the students examine what advantages each plane has. Then, each group decides how they want to improve their plane and remake it using the design ideas from the other groups as well as their own ideas. Each group iterates trying to reach their goal.

Making a Paper Airplane

Materials

- Several pieces of copier paper
- Adhesive tape, paper clip, penny, stapler (optional)

Folding the Paper Airplanes

Assign each group an airplane design. See attached document. Designs A, B, and C are fairly straightforward to fold, but Design D is a bit trickier. You may consider only assigning that design to more expert groups. Have the group fold their design several times. Subtle changes in the folding can have significant effects in the final product.

The groups should fly their planes to determine some of the characteristics of their plane. They will need to throw the planes several times. A long hallway, a gym, or an auditorium works well as a place to throw. They will probably notice that qualities of the throw -- flat, angled, curved -- are important, and they will need to throw several times with each version of their plane to really get a sense of how each plane works.

Characterizing the Planes

The students will probably notice that the different designs of the planes don't behave all the same. As a class, they should determine ways to classify the planes qualities. You may need to help younger students figure out some possibilities. For example, they may notice that

- Some planes fly farther than others.
- Some planes stay aloft for longer than others.
- Some planes can do loops (are less stable) than others.
- Some planes look cooler than others.

Have the groups try to come up with ways to quantify the qualities of the planes based on the criteria they developed above, taking into account that not every throw is the same and not even every folding is the same. They might decide on some combination of these:

- Average three or more throws.
- Add together the results of five throws but discard the biggest and the smallest.
- Take the highest throw of several throws.
- Have all the throws done by the same person.
- Have each person in the group throw the plane.
- Discard results where an obvious mistake occurred.
- Discard results when a gust of wind or something external interferes.
- Have many practice runs but then once taking data, collect all results.

Students will often have strong opinions about which methods are the most fair, but really all of these and many other methods have merit. Which one to use depends on what concerns seem to be the most important. Controlling variables is easy for many experiments, but in this situation it can be much harder. Even if the group had the same person always making the throw, the throwers in other groups might be better at throwing, making their planes seem better. If the whole class always had the same person make the throw, that person might have a throw that favors some kinds of designs over others. Even then, the thrower might not always have the same release every time.

In addition, as the teacher, you might have goals beyond science and engineering. For instance, if you want to get all the students in a group involved, you might have every student fold a plane and throw it, but then a student who makes a mistake or with poor dexterity can really penalize the group. Perhaps by dropping the highest and the lowest result that concern is somewhat ameliorated. On the other hand, maybe it is important to design a plane that works for all students and not just the students in the middle. Different goals will lead to different testing regimes.

Some things, like the beauty of the design, are hard to quantify, but they can be very important in real engineering. Many real products are more expensive or have lower performance so that they can be more stylish.

Improving the Plane

Students should use Shaesta Waiz as an example. Ask students what she did according to the video. For younger students, you'll probably need to give some scaffolding. Explain that while she started with a standard plane, she made changes to the plane. You might ask

- What were Shaesta Waiz's goal for the plane? (safety and extra distance)
- What kind of changes she made? (extra tanks).
- Do you think that she tested those changes before she started on her journey? (of course).
- Do you think that she might have made changes after she made the tests to make her plane even better? (yes)
- Do you think that some of the features of the original plane were sacrificed? (probably speed and carrying capacity due to the extra weight of the tanks and fuel)

Like Shaesta Waiz, each group should make a plan to improve their airplane. Maybe they want it to fly farther or stay in the air longer. The students should examine the data that the class has collected and use it to make a change to their plane. They might completely scrap their designs, or they might need to make just a few modifications. After making changes and refolding their planes, they should retest using the criteria they set out before. They should then repeat by making new changes and retesting, recording each time what seems to work and what doesn't.

Since it isn't too time consuming to try new designs, and since what works well isn't obvious, creativity will play a particularly important role in finding the optimum designs. You may wish to let students include the optional materials to give new variables to test.

While many teachers would be inclined to assign a single task for the class, letting each group set its own goal has many advantages. Students tend to be more invested in the design and work harder. Groups don't just copy the work of other groups. Voices that are less often heard get a chance to shine.

Help students to understand that this is the engineering process. Engineering uses a cycle of

- determining a problem
- identifying what's needed to solve the problem
- trying and testing possible solutions
- optimizing
- iterating

As the available time runs out help students to summarize the science that is important for paper airplanes. They should notice things like

- Gravity pulls the plane down.
- Air can bounce off the plane's wings, imparting a force from Newton's Third Law that pushes the plane.
- Paper airplanes start with a certain amount of energy, some of which is the kinetic energy of their motion and the gravitational potential energy from the plane's height off the ground.

- As the plane goes down some of its gravitational energy can become kinetic energy.
- Wind resistance steals away kinetic energy, slowing the plane.

Part III: Evaluation

While many kinds of assessment work, the students and the teacher should assess how well they improved their airplane. What did they learn about how paper airplanes work? You could write an assessment that offers possible changes and asks students to predict how that will improve or hurt a paper airplane.

In addition, each group should report out on how well they worked together. Having the students briefly present their work to their classmates tends to give the best opportunity to figure out what happened in their group. They should explain

- What their problem/goal was
- What they tried
- Whether or not it was successful
- How they could tell if it was working
- What they did if they didn't all agree on what to do
- How often did they get to put a mark on their checklists