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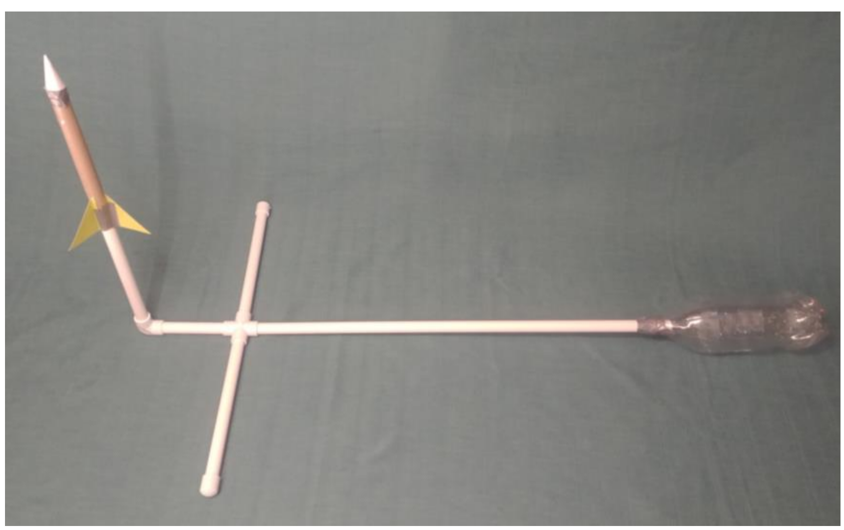
SHAYNA BEGAY

Launching Rockets to Become a Great Engineer

STEM Lesson Plan for Grades 6-8

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



Many engineering projects though 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 adequate solution is what makes an engineering project.

NGSS Standards
CCC: Structure and Function
ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions
ETS1.C: Optimizing the Design

In this lesson plan, students will watch a video where Shayna Begay explains how she became a successful engineer. After figuring out what she says are some key factors to being a great engineer, the students will launch some paper rockets. By examining how well they fly, the students will set goals for themselves to improve their rockets and will work iteratively to improve their design and launch parameters. At the end, they will examine what behaviors they used to be successful.

Part I: Watching the Shayna Begay 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

Shayna Begay said that she had to overcome the obstacles of _________

Shayna Begay 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:

- Shayna Begay succeeded as an engineer because she has perseverance.
- Shayna Begay succeeded as an engineer because of teamwork.
- Shayna Begay went into engineering because she wanted to help 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	~~||||~~ |

I didn't give up when something didn't go the way I planned	~~||||~~ |||

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

This engineering activity involves shooting paper rockets. While the pressures and speeds are low, there is a small chance of injury. Students should never shoot rockets at another person. All people should wear eye protection at all times. Only students familiar with PVC cutters or hacksaws should use them. This activity works fine if the teacher makes all the cuts in advance.

In this activity students will make a homemade rocket launcher and paper rockets. By crushing a 2-liter bottle, a jet of air will rush into a paper tube, launching it into the air. After some initial exploratoration, students will pick an attribute of their rocket to improve. After the teacher sets a reasonable goal, the students will iteratively make changes to their design, build the rocket to the new specification, test to see if it now meets the goal, evaluate the results, and then propose new changes if necessary. At the end, the groups should have rockets that excel in a variety of ways.

Materials

- Safety glasses for all participants
- 10 feet ½-inch PVC pipe, cut into pieces as follows: 2 12-inch pieces, 1 6-inch piece, 1 24-inch piece, 1 18-inch piece, additional pieces to be used as forms
- 1 ½-inch PVC cross connector (slip)
- 1 ½-inch PVC 90-degree elbow (slip)
- 2 ½-inch PVC end caps (slip)
- 1 plastic 2 L bottle (plus additional as the first one wears out)
- PVC cutter or hacksaw
- Duct tape
- Construction, paper bag, or copier paper
- Masking tape
- Scissors
- Protractor, straw, 3-inch piece of string, weight (optional)
- Traffic cone or other target (optional)
- 100-foot measuring tape or string (optional)
- Stopwatch (optional)
- Model rocket altitude finder (or protractor and string)

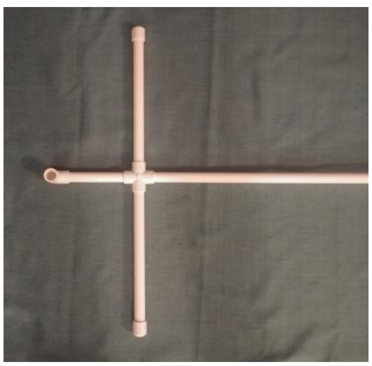
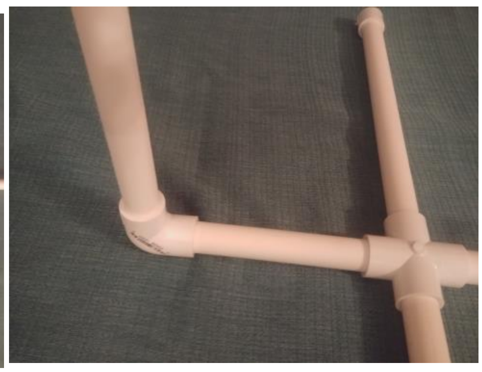
Assembly and First Launch

1. Using the PVC cutter or a hacksaw, cut pieces to the lengths above.
2. Slip the elbow over one end of the 6-inch piece of PVC.

3. Slip one end cap to each 12-inch piece of PVC.

4. Slip the two 12-inch pieces to opposite sides of the cross connector.

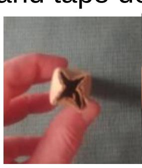
5. Slip the 6-inch piece into the cross connector. Twist so that the 90-degree connector has the hole facing up. Slip the 24-inch piece to the other side. Slip the 18-inch piece into the 90-degree connector so that it is normal (perpendicular) to the ground.

6. Using duct tape, attach the end of the 2-liter bottle to the 24-inch piece of PVC.

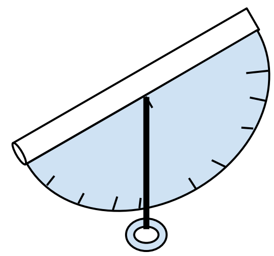
7. Using an additional piece of PVC as a form, wrap the paper around the pipe. It should be form fitti … er into a tube.

8. Remove the paper tube from the form. Squeeze the end of the tube together, fold over and tape down. The rocket can fired at this stage.

9. (Optional) To make a nose cone, cut a semi-circle out of a sheet of paper. Roll into a cone with curved portion on the bottom. Use duct tape to attach to the tube.


10. (Optional) To make fins, cut triangles out of paper or cardstock. Fold over an edge and attach to the tube with duct tape.
11. Slide the rocket over the vertical tube. Make sure that the rocket can slide easily on the tube. Move your foot downwards quickly to fire the rocket.
12. The optional equipment can be used to find additional information about the launch. The angle of the launch can be adjusted by changing the angle of the 90-degree connector. You can use a protractor, straw, and a weight to find the launch angle. With math this can also be used to find the height. A model rocket altitude finder can be used. A stopwatch can be used to tell the time aloft. The cone can be used for a target. The long tape can be used to find out how far the rocket traveled.



13. Have students launch several rockets to get a feel for how the rockets work. A gymnasium or large cafeteria with a high ceiling make good launching zones. Outdoor spaces work fine as long as it isn't very windy. Remember that it may be windier above ground level. Ask the students to keep notes about what they think makes different components have different effects.

14.

Characterizing the Rockets and the Launchers and Finding a Goal

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

- Some rockets fly higher than others.
- Some rockets stay aloft for longer than others.
- Some rockets travel farther than others.
- Some rockets are more accurate (land in a repeatable location) than others.
- Some rockets look cooler than others.

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

- Average three or more launches.
- Add together the results of five launches but discard the biggest and the smallest.
- Take the highest launch of several throws.

- Have all the bottle crushes done by the same person.
- Have each person in the group launch the rocket
- Discard results when a gust of wind or something external interferes.

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 much harder. Even if the group had the same person always stomping on the bottle, a foot might come down differently each time. 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.

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 to have every student build a rocket and stomp on the bottle, 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. Different goals will lead to different testing regimes.

After the groups have become familiar with the rockets, each group should pick a goal for their rocket. Do they want the rocket to reach a certain height? Remain in the air for a particular time? Go some distance? Hit a particular target? While it might seem better for the whole class to have the same goal, students are more likely to become invested in a goal of their own choosing. Further, real engineering is usually an attempt to meet adequately a set of criteria within constraints and not a competition for the best or the greatest.

Based on their starting information, help the students set reasonable goals. For example, if the group got a rocket to reach 100 feet upwards, their goal might be to get the rocket to go 150 feet. Another group might try to get their rocket to land within five feet of a target that is 50 feet away after being able to only get it within 10 feet of the target earlier.

Have students keep track of their trials in a notebook. Photographs and videos of their work can be very helpful. If the goals are appropriately challenging, students will often seek help from their teachers as they get stuck and need the next idea. Examining their prior work is usually helpful, but if they haven't kept enough data, like distances, angles, weights, fin designs, it won't be possible. Students may have to repeat some of their trials to get enough data to draw conclusions. Allow this happen with good grace, nothing makes students more willing to keep notebooks as finding that they are useful.

At intervals, you wish to have groups report out to their classmates what they think that have discovered. They are likely to notice that

- Harder stomps make the rocket leave the launcher at a higher speed.
- Longer rockets (up to a point) go faster.
- Nose cones and fins make the rocket go straighter.
- Heavier rockets don't go as far.

- Rockets that are too loose around the launching pipe don’t launch at a high speed. Rockets that are too tight around the launching pipe also don’t launch at a high speed.
- The angle of the launch relates to the distance the rocket goes. High angles go up higher but not far along the ground. Lower angles go faster parallel to the ground but don’t stay in the air as long.

Encourage students to ask each other, “How do you this?” Encourage students to be reasonably skeptical and politely ask for evidence from each other. Since the groups aren’t competing with each other, they are usually willing to be more forthcoming.

As groups meet their goals, encourage them to select new goals that are different from their first set. For example, if one group has hit their height goal, have them try to figure out how to make an accurate shot. This encourages more experimentation and data collection and helps contribute to a better understanding of the material.

Part III: Evaluation

While many kinds of assessment work, the students and the teacher should assess how well they improved their rocket launch. You could write an assessment that offers possible changes and asks students to predict how that will improve or hurt rocket launch.

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