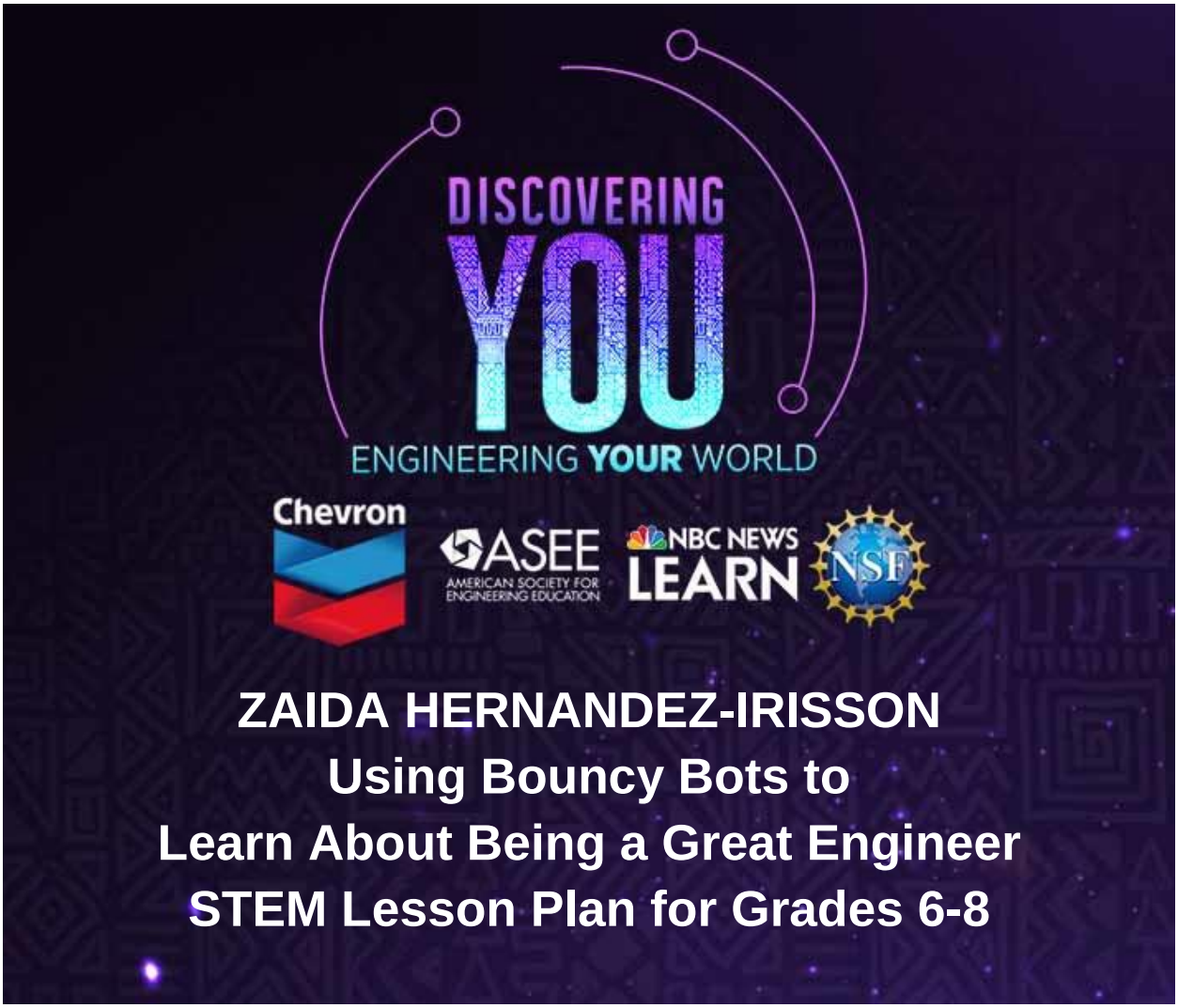
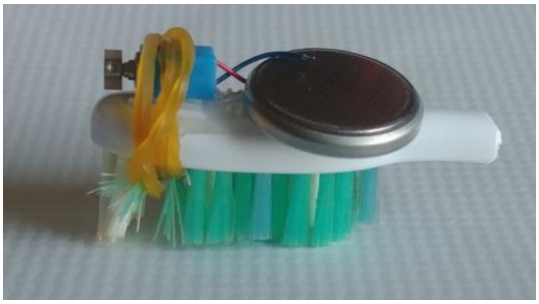


Helping all students, especially girls, to be interested in engineering as a possible future can be challenging. Research suggests that role models are important for helping students to see themselves in a jobs where they have been underrepresented. In addition, having challenging and fun engineering 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 a satisfactory solution is what makes an engineering project.

In this lesson plan, students will watch a video where Zaida Hernandez-Irisson explains how she became a successful engineer. After figuring out what she says are some key factors to being a good engineer, they will embark on an engineering project where they will identify a problem and try to develop a solution. Finally, they will look back at their work habits to determine how closely they matched skills that the engineer suggested were important.

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

PS2.A: Forces and Motion
Newton's second law accurately predicts changes in the motion of macroscopic objects.
PS2.A: Forces and Motion
For any pair of interacting objects, the force
exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction.

Part I: Watching the Zaida Hernandez-Irisson 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

Zaida Hernandez-Irisson said that she had to overcome the obstacles of _____

Zaida Hernandez-Irisson said that she want 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:

- Zaida Hernandez-Irisson is an engineer because she wants to help people.
- Zaida Hernandez-Irisson has made engineering her career.
- Zaida Hernandez-Irisson mentors and helps others.
- Zaida Hernandez-Irisson persevered to overcome obstacles.
- Zaida Hernandez-Irisson was true to herself.

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	𝍸 I
I didn't give up when something didn't go as planned.	𝍸 II

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 a good engineers.

Part II: Engineering Cycle

In groups of about four, have students build the Bouncing Robots described below. For younger students, you may need to do things like cut the toothbrush in advance. Help students get as far as getting the robot to move and then have them stop. I know that will be hard. Promise that they will get to come back to the project afterwards.

Making Bouncing Robots

If you attach a small motor with an offset weight to a toothbrush, the toothbrush will bounce up and down. Tuned correctly, the toothbrush can be made to move around a surface.

Materials

[a photo of materials will appear in the final version]

- Small pager/cellphone motor (typically 3V)
- Toothbrush
- 3V battery (for example, CR 2032) or 1.5 V AA or AAA battery
- Sticky foam tape or glue tape, approximately 1 cm x 3 cm (½ inch x 2 inches) or hot glue (low temperature)
- 2 or 3 small rubber bands

Assembly

(Note this assembly hasn't been optimized! This is just enough to make the brush jump around.)

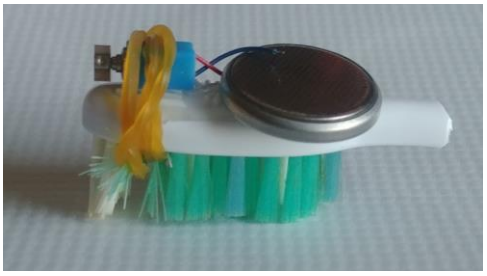
1. Cut the toothbrush's handle off so that approximately 1 cm (½ inch) of it remains attached to the brush. A hacksaw works well for this as do kitchen scissors. You can

also use a wire cutter.

2. Cut the foam tape so that it fits the back of the toothbrush and apply to the brush.

3. Place the motor on one end of the brush on top of the tape. Push down lightly. The motor should still be able to be removed, but it should be able to stay in place during shaking.Hold the motor down further by wrapping the motor to the toothbrush with a rubber band.

4. Take one end of the motor's wire and place it on the foam. Place the positive (+) side of the battery on the wire and stick to the foam. Touch the other end of the motor's wire to the battery to make sure the motor spins. If it doesn't reverse the wires.



5. When you are ready to activate the Bouncy Bot, place the other wire on the battery and hold in place with second rubber band.

6. If using a AAA battery, place the battery on the sticky foam. Make secure with a rubber band. Place one wire from the motor on one side of the AAA battery. Place the other wire from the motor on the other side of the battery and hold in place with a third rubber band.

After the students have gotten the robot to function, have them stop working for a moment, and describe what their robot can do.

Improving the Robot

In groups, have the students make a goal for their robots. For less experienced students, you might want to offer some suggestions like

- Our robot should go as fast as possible.
- Our robot should go as slowly as possible without completely stopping.
- Our robot should go in spirals.

While these robots can be just toys -- and they make good pieces for table top sports games -- students can also try to think of things that these robots might be able to do that other robots wouldn't be able to do. That is, ask the students to speculate on some problems that these robots might do better than other things. For example, they might think about how these robots move across the ground without wheels, being able to cover soft material in ways that wheels might cut into the ground, or they might speculate that the unpredictable motion of the robots might make them harder to track.

Many ideas will need additional materials. We typically offer:

- masking tape
- additional batteries
- pipe cleaners
- modeling clay, scissors for modifying the bristles
- string
- extra motors
- paper clips

and whatever else we have on hand.

Some ideas may end up being impossible. Their robots probably can't be made to fly without throwing them, but perhaps you can redirect. Maybe their robot should be able to keep moving

after it has been dropped. Many groups want their robot to write their names. This at first seemed very difficult, but one group used tape to make a fence-like border and water to be spread by the bristles. It more or less wrote their names.

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.

Their idea is now a problem to solve. Now they will use the engineering cycle which the teacher may need to write on the board or as a handout.

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

to work towards improving their Bouncing Bot.

Students should make as many iterations as they can. If they have access to cameras, taking pictures or short videos is a great way for students to see their progress.

Part III: Evaluation

While many kinds of assessment work, having the students briefly present their work to their classmates tends to give you 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

Creating a rubric can help in grading. However, remember that the groups are determining their own problems, and they should be measured in how close they were succeeding in meeting their own standards. Progress is often the best measure.