Engineer a Stringed Instrument

In this activity, youth engineer a musical instrument that produces three different pitches. Using a simple engineering design process, they imagine multiple solutions to their challenge, establish criteria and constraints for their design, and use readily available materials to design and test it.

Timing: 90 minutes, divided into 12 distinct steps.
This lesson can easily be broken into multiple sessions.

Materials:

Assorted household supplies (materials can vary)
Engineering Journal

Step 1: What is Engineering? (5 min.)

Engineers solve problems by designing objects and processes.

- *What kinds of things do you think engineers have designed that help musicians? (instruments, music stands, microphones, recording equipment, headphones)*

Engineers often use an engineering design process (EDP) like the one shown in your Engineering Journal.

- *Why do you think engineers use this tool?*

Step 2: Learn about sound and stringed instruments (5 min.)

Throughout history and across cultures, people have engineered stringed instruments to make music. The Engineering Journal shows some of these from around the world.

- *What features do these instruments share?*

You may have noticed that to create sound, all stringed instruments have a body and strings. Sounds are waves that move through the air. Engineers have designed features that make the sound of stringed instruments louder, clearer, higher and lower, and more resonant. Look at the pictures of guitar parts in your Engineering Journal.

- *Which of the guitar parts shown help control pitch (how high or low a sound is)? (the neck, the tuning pegs)*
- *Which parts help improve sound quality? (the bridge, the sound hole)*

Step 3: Decide on criteria (5 min.)

Your engineering challenge is to design a stringed musical instrument (or instruments) that can create three different pitches—high, medium, low. At least one of the sounds must be able to be changed by making an adjustment to the instrument.

The instrument design has two parts:

- The body (cardboard box, plastic storage container, rectangular pan)
- The strings (elastic bands, string, wire)

To solve any problem, engineers need to know the requirements, or **criteria,** for the end product. Look at the *Design Criteria and Testing Results* table in your Engineering Journal. It shows that your instrument must:

- Create three distinct pitches (high, med, and low)
- Have one sound that is adjustable

In addition, you must choose one other feature your instrument will have. Choose one criterion from the list below (or make up your own) and add it to the criteria column in your Engineering Journal.

- Can be adjusted for volume (how loud or soft it is)
- Produces 5 pitches instead of 3
- Includes a bridge that elevates the strings to vibrate
- Has a sound hole in the body to help project sound
- Is collapsible for storage
- Is environmentally friendly (made of recycled/recyclable materials)
- Other: A criteria you identify: My instrument will: _____.

Engineers' designs also need to consider **constraints**, or limitations. This instrument should be less than 36 inches long.

Step 4: Prepare for testing (5 min.)

Engineers use tests to determine whether their designs meet the goals they set. Thinking about these tests early in the engineering process helps engineers brainstorm solutions that will be successful.

The second column of the *Design Criteria and Testing Results* table shows how you will test your instrument to make sure it produces three distinct notes and that one note can change its sound when adjusted.

- *How you might test the third criterion you selected? Add your ideas to the table in the Engineering Journal.*

Step 5: Think about materials (5 min.)

Engineers carefully choose materials that will help them design a product that meets all the requirements. Based on your design criteria:

- *What materials might work well for the body of the instrument?*
- *For the strings?*

Discuss your ideas with a partner, group, or instructor.

- *Why do you think the materials you chose will work well?*
- *What properties do they have?*
- *What other materials could you use to create this design?*

Step 6: Collect your materials (10 min.)

Based on the properties you described, gather materials that could be used to make your instrument. If you can't find the exact material, look for one with similar properties. Share the materials you found with a partner, group, or instructor.
Be sure to:

- Make sure it's OK to use them! (Ask permission if you need to.)
- Gather any tools you might need to build the instrument (for example, scissors, tape, glue, stapler, etc.)

Step 7: Brainstorm ideas (10 min.)

Engineers come up with creative ways to solve problems by considering many different ideas before deciding what to make. They talk with their teammates to get even more ideas. All designs are strengthened by feedback from others.

Using your Engineering Journal, sketch out at least 2 possible designs for your instrument. Sketch your instrument and show how the strings will be attached to the body. Think creatively!

Share both of your design ideas with a partner or the group. Notice what different ideas they have generated—there are many possible ways to solve this challenge. Make tweaks to your designs based on others' ideas (resketch if necessary).

If you don't have time to complete this activity in one session, take a break here and come back later! Put the materials you collected and your Engineering Journal in a safe place until next time.

Step 8: Choose one design to try out (10 min.)

After brainstorming many different ideas, engineers choose one design that they will build and test. The chosen design combines the best elements of all their ideas. Before starting to build, they draw a detailed plan of their design, and list or label the materials they will use.

Using your Engineering Journal, draw a final plan for the design you want to build and test. Be sure to label your drawing and write down how much of each material you will need.

Step 9: Build and test your instrument (15 min.)

Follow your plan and create your instrument!

When you are finished, test how well your instrument works by using the testing methods in your Engineering Journal. Be sure to log the results of your tests in the third column of the table.

- *How did it work?*

Step 10: Communicate and participate (5 min.)

Engineers communicate their designs with others. They share their work with other engineers, with the clients that ordered their products, or with the general public.

Take turns introducing your instrument to a partner, group, or instructor.

- *Describe your design and the criteria you were trying to meet.*
- *Perform your test sequence to show how it works.*
- *Ask others to provide feedback on your design.*

Think about how you can provide good feedback to your peers.

- *I like how your design _____.*
- *One thing you might try is _____.*

What similarities and differences are there in instrument designs?

Step 11: Try again! (10 min.)

Engineers are always striving to make their designs better. They go through the phases of the EDP over and over again because they learn something new every time they design.

- *Think about how you can make your instrument better based on the feedback.*
- *Redesign, test, and share your modifications.*
- *Did it perform better?*
- *If you had the opportunity make another instrument, what new features might you include in your design?*

Step 12: This is Engineering! (5 min.)

As engineers solve problems by designing objects and processes, they use an engineering design process (EDP) like the one shown here. You are an engineer!

- *Looking at the EDP, reflect on process you used to create the instrument.*
- *What did you do during each phase? (Ask, Imagine, Plan, Create, Test, Improve)*
- *How did using a process help you engineer?*

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