LESSON PLAN: Hover Design Challenge

Description:
During this engineering based lesson, students build, test and modify hovering devices in a wind tunnel to expand knowledge of design and aerodynamics.

Grade Levels:
3-12

Duration:
50-60 minutes

Tech Tip:
Sharing Solutions

The Tech Challenge Connections:

- For this lesson, students design and build a craft to start thinking about generating and testing ideas for modifications that impact performance. This activity also gives students a chance to rapid prototype as part of a class team and share solutions to develop ideas. Both of these skills are highly useful to participants as they build, test, and document their ideas and solutions for the Tech Challenge.

Objectives:
Students will

- Learn that they can take a design parameter and explore it through rapid prototyping.
- Practice analyzing a problem with a team.
- Practice optimizing solutions.

Standards Connections:
This engineering design challenge connects with NGSS Science and Engineering Practices and Standards at all grades.

Grade level modifications:
This activity can be scaled for grades 3 and up. Some scaling of the activity is inherent to the participants. Those older or more experienced with building will engineer more sophisticated designs more quickly, resulting in more iterations and complex designs. For students with less engineering and design experience, you may want to scaffold ways to brainstorm, share solutions, and explain their process.

Materials:

Rigid Materials	Flexible Materials	Connectors
• Straws • Small craft sticks • Clean, plastic food containers (ex: yogurt cups) • Cardboard food containers • Cardboard tubes • Corks • Toothpicks/bamboo skewers	• Foam shapes • Coffee filters • Lightweight fabric scraps • Foil sheets • Paper	• Rubber bands, varying thicknesses and lengths • Pipe cleaners • Foam shapes • Paper clips, binder clips • Corks • Toothpicks/bamboo skewers

*We leave tape and glue off this list on purpose. Though classified as "connectors," forgoing tape and glue will allow for rapid iteration of designs. This also will allow you to recycle and reuse materials for another session.

Test Rig (Wind Tube)
• Small fan (able to tilt and point vertically) • 4ft x 4ft sheet of acetate plastic • Three embroidery hoops (matching diameter of your fan) • Three wooden spacers 2in x 2in x 6in • Three large binder clips • Three 7in cable ties • Masking tape/painters tape • Scissors • Hand drill • Saw • (Optional) Build a honeycomb of straws to reduce turbulence (diffuser)

Prep:

- Collect materials.
- Build test rig (wind tube). https://www.exploratorium.edu/pie/downloads/Wind_Tubes.pdf
- Mark a "target zone" with masking/painters tape by placing two pieces of tape around the tube, 12 inches apart, starting one-third of the way up the tube from the fan.
- Set up a materials area and team spaces to build.
- Set up a testing zone. Set up wind tube. Delineate a "testing zone" with tape on the floor (2-3 feet in diameter around the wind tube.) Teams should test one by one.

Lesson:

1. Introduce the hovercraft and Design Challenge (3 minutes).
    a. Discuss what makes a hovercraft an interesting form of transportation.
        i. *Who has seen/been on a hovercraft before? Can you describe it (that experience)?*
        ii. *Does anyone have an idea how they work?*
        iii. *Why would having a vehicle that hovers be useful?* (Answers include: terrain is unknown, the land cannot be damaged, it's neat.)
    b. *We will be doing two design challenges. In our first Design Challenge, we will explore air currents and how our devices interact with those currents.*

2. Introduce first Design Challenge (15-20 minutes).

Design Challenge 1: Build a device that will float up and out of the wind tube on the air currents generated by the fan.
Criteria: • Device must fit into the wind tunnel (opening and tube)
Constraints: • Budget: Materials ONLY provided by facilitator • Schedule: Build time (10-15 minutes)

Divide the group into teams of 2 to 4 and have them start.
Remind students to test devices and materials early and often during the build time!

3. Gather the class together for a demonstration and sharing of devices, see Tech Tip: Sharing Solutions (10 minutes).
    a. Have each team present their device (one team at a time).
        i. Share Solutions: *Tell us how your device was intended to work. After testing, what changes to your device did you make and why?*
        ii. Students demonstrate their devices.
        iii. Reflection: *If you had more time or materials, what would your team try next?*
    b. *During this design challenge we focused on how air currents interacted to give our designs lift. Now that we have some experience with the materials, let's shift to designing a device that will hover inside the tube but* ***not*** *float out.*
        i. Does anyone want to share a few thoughts on how our first challenge could inform your second challenge? (Possible answers include: don't want it to tip over, can't catch too much wind.)

4. Have students use what they learned from the first build, share out and develop a design to meet the new challenge. Remind students to test devices and materials early and often in the wind tunnel (15 minutes)!

Design Challenge 2: Make a device that will hover in the target zone of the wind tube.
Criteria: • Device must fit into the wind tunnel (opening and tube) • Device must settle into and hover within target zone
Constraints: • Budget: Materials ONLY provided by facilitator • Schedule: Build time (15 minutes)

5. Gather the class together to do a final test and share out, see Tech Tip: Sharing Solutions. Discuss modifications, criteria and constraints students used to create their devices (10 minutes).
    a. Have teach team share: Tell us how your device was intended to work. *What changes did you make and why after testing?*
    b. Then demonstrate their device.
    c. Have them share: *If you had more time or materials, what would your team try next?*

6. Alternate share out - reflect on devices and their performance (7 minutes).
    *a. What was the key to getting your device to hover? (*Follow-up: device's weight, aerodynamics, balance, or something else?)
    b. What modification did you make and why after testing?
    c. If you had more time or materials, what would your team try next?

7. Students take apart devices and re-sort materials. Or, save devices if you plan on continuing the challenge.