Day 1 - Engineering Design Principles with Cubelets,
Introduction to Engineering Thinking

For each class/group, this lesson plan includes 2 parts, 20 Minutes each:

1. An introduction to the basic concepts and vocabulary of engineers by engaging students in an “unplugged” thought-based activity
2. A hands-on component using Cubelets to reinforce the concepts and vocabulary presented in part 1

This lesson plan is geared towards 4th - 8th grade classes, though adjustments to vocabulary and descriptions, and providing more or less guidance allows teachers to use this with younger or older students. However, using these ideas, instructors, science centers, club leaders, and classroom teachers are invited to recast this material to work for other settings.

Introduce students to kinds engineering and engineering problem-solving

“Engineers are a kind of scientist that use their skills and creativity to solve problems or change a situation by designing or making something innovative. Engineers work in lots of fields making foods, buildings, chemicals, machines, bridges and more. Whatever fields they work in, they follow a similar process and ask the same questions:

First - What is the problem? What situation would we like to change? Second - What kinds of solutions could make this better? What could we make that would change this situation? Third - When we try our solution - how well does it work? How do we know if this solution was successful?

Let’s see how this would work by thinking through a scenario where engineers might be asked to help.”

Some of the different kinds of engineers are:

Mechanical - mechanical engineers make machines like cars, toys, robots, and wind turbines. These engineers might be Industrial, Materials, or Aerospace Engineers.

Civil - These are engineers that work to to plan structures and systems of structures like buildings, highways, airports, and bridges. This type of engineer might work as an Architect, City Planner, or work in transportation.

Chemical and Biological - Chemical engineers might make prescriptions, food products, or chemicals that help us in other ways like cleaning and safety. Biological engineering is a broad area that includes making creating medical solutions for doctors to use, but can also include agriculture, like how to improve farming practices and food products. This category could also include environmental engineers working to make energy, buildings, and cities more sustainable.

Electrical and Software - This includes people who design and make electronics and computers, but also engineers that write and implement programs to run computers and devices. This may also include engineers who work to harness energy in innovative ways.
Part 1: Understanding Engineers and Problem solving

Materials: Print out these scenarios and worksheets for students or work through them as a group and/or out loud.

Students consider how engineers make lots of different things, and how different kinds of engineers and innovations may combine to address problems, challenges, or situations people wish to change.

Let’s talk about one of these stories together, and then you can pick one of the remaining stories to think through on your own. You will need to pick the kind or kinds of engineers that could address this challenge, and answer three questions:

First - What is the problem? What situation would we like to change?
Second - What kinds of solutions could make this better? What could we make that would change this situation?
Third - When we try our solution - how well does it work? How do we know if this solution was successful?

1. A fancy restaurant in Phoenix, AZ wanted to save more of the money they make by paying less to food suppliers. They also noticed some of their bills were really high at the end of every month - they were paying a lot to their electricity company, spending a lot on fuel for their stoves, and because the restaurant was in a really warm place, their air conditioning was running for 9 out of the 12 months of the year! What kinds of solutions might work and what kinds of engineers can help solve these problems?

2. A new town noticed that they were such a pretty, clean, happy place to live that more and more people wanted to move there. The only issues this town has is occasional earthquakes and being a little isolated from other towns and cities. As a small town, everyone there was able to walk or bike to work and school so they had very little air pollution. While they considered building more houses, apartments, schools, office buildings, and stores to grow their town, they also wanted to keep the air, ground, water and streets in their town clean. They also thought that if the town was going to get bigger, they should help the residents be able to get to and from other towns. What kinds of engineers might help the townspeople to plan to expand their town, provide transportation options to other town, but keep the town very clean and safe?

3. A magician wanted to put a new trick into his show. He had an idea to stand high on a platform, wave his cape, throw his top‐hat (with his rabbit inside!) disappear, and then reappear again on the stage before the hat and rabbit hit the stage floor. What kinds of inventions and innovations could help him accomplish this illusion? What kinds of engineers could help him?

4. A mad scientist thought that people would eat more brussel sprouts if they tasted like graham crackers, and eat more broccoli if it tasted like chocolate, and more spinach if it tasted like marshmallows. He wants to make these vegetables with different tastes, but without losing any of their vitamins, fiber, or healthy food properties. He also wants to make them locally, and find a way to box, bag, package, and ship them without using harmful plastics or too much fuel. What kinds of inventions, innovations, and solutions does he need to go from this idea to having broccoli‐chocolate in a grocery store? What kinds of engineers could help him?

Concepts presented: Engineering design process, innovative problem solving , collaborative problem solving
Vocabulary: Engineering, define, innovate, invent, design, civil, agriculture, mechanical, aerospace, environment, sustainability, systems, structures, process, situation
Part 2: Hands-on with Cubelets robots

Materials: Educator Pack of Cubelets. Students should plan to share 1 Battery Cubelet and 2 senses, 2 actions, and 1-2 Think Cubelets in groups of 2-5 students. Using One Educator Pack, not all groups can complete all challenges at the same time. You may consider having different groups work on different challenges.

Students now practice the Engineer Design cycle by defining problems, building a potential solution, and testing their innovation. We recommend introducing students to Cubelets work for 5-10 minutes of guided play, and then having students choose one or two challenges for the remaining time.

Introduce students to using Cubelets: “Now we’re going to practice being engineers and problem solving using these Cubelets to build robots. Robots are devices that sense, think, and act. Black Cubelets have senses, like our eyes and ears. Clear Cubelets are the action parts of the robots that do things. Colored Cubelets are the thinking or logic parts of the robot. Here’s a really simple robot to using this Brightness Sense, and this Flashlight action - when the sense sees a lot of light in this room, this action has a bigger reaction (light comes on). Or we can trick it by making this sense see less light (cover sensor face) and what happens? (The light goes out). We can extend it using this Passive Cubelet and we can move all these pieces around because they all connect magnetically and talk to each other. We can make driving robots of all kinds using different senses and actions. We can also use colored Cubelets to change the information between senses and actions. (A great example of this is to use the knob and Bar Graph, and then use Inverse Cubelet between this sense and action to illustrate how this addition turns “a big input into a small action and a small input into a big action.”)"

Cubelets Challenges: For each of these, be sure to remind students “What is the problem? Can you make something that solves it? Now try it – how will you know it is successful?”

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<thead>
<tr>
<th>Challenge 1</th>
<th>Challenge 2</th>
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<tbody>
<tr>
<td>Someone keeps stealing your toys! How can you make a motion activated light that will alert you when someone gets close to your toys?</td>
<td>Your power has gone out and your freezer won’t stay cold forever. Can you make an alarm that will let you know when things are warming up so your ice cream won’t melt?</td>
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<td><img src="https://example.com/image2.png" alt="Image 2" /></td>
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<th>Challenge 4</th>
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<td>You’re having a party with 4 different kinds of cupcakes! How can you make a robot that will turn without stopping, while holding a plate on it? Use your box as a pretend plate for this.</td>
<td>You are in a dark basement and don’t know where the lights are. You don’t have a flashlight or candle, but you do have Cubelets! How can you make a robot flashlight that will stay lit while it’s dark but go out and conserve power when you get into the light?</td>
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Concepts Presented: engineering design cycle, testing success, solving problems as an engineer
Vocabulary: define, engineer, solution, problem, challenge, device, mechanical, potential
Appendix: Worksheet

This worksheet can be used to facilitate students thinking through the engineering scenarios

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<td>This includes people who design and make electronics and computers, but also engineers that write and implement programs to run computers and devices. This may also include engineers who work to harness energy in innovative ways.</td>
<td>Chemical engineers design chemicals that help us to clean, keep things safe, make food, or medicine. Biological engineering includes creating medical solutions, agricultural solutions, like how to improve farming practices and food products. This category could also include environmental engineers working to make energy, buildings, and cities more sustainable.</td>
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For Each Story Answer the following questions:

**First** - What is the problem? What situation would we like the change?
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**Second** - What kinds of solutions could make this better? What could we make that would change this situation?
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**Third** - When we try our solution - how well does it work? How do we know if this solution was successful?
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