Family Makers | **Intro to Engineering Design Process** | **Session 1**

Audience: Families with K-5 children
Session: Session 1
Time: 80+ minutes
Topic: Introduction to the engineering design process
Question: What is the engineering design process, and how can we use it to build and improve solutions?

Session structure:

For online program (in Zoom)

- **Ignite (20 min)**: Builds relationships and ignites interest in engineering
  - Icebreaking activity: Treasure hunt to find a meaningful item and learn about each other
  - Driving Question (DQ) and Engineering is Elementary (EiE) process
  - Connect: Watch a video clip to share examples of engaging in EiE
- **Make (50 min)**: Supports families' externalization of ideas and solutions
  - Simple challenge: Participants build the tallest and strongest tower they can and then test it with weight (pencils) or simulated wind
  - Complex challenge: Participants build the tallest and strongest tower they can and then test it with weight (pencils) or simulated wind
- **Reflect (10 min)**: Promotes families to identify which shapes and techniques worked best and share their findings with the group

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Customizing your script:

- Important: Throughout this curriculum, whenever you see "Note" in red, it means you can adapt, customize, or change that section based on your specific situation. Feel free to tweak, adapt, or completely remove these sections to match your local context.

Facilitation notes:

- While *Family Makers* was originally designed as an online program, this exact same curriculum can easily be run as an in-person library program or other formats you choose (i.e., drop-in stations, take-and-make kits, social media challenges). Check out the resources for flexible implementation on Family Makers website.
- Regardless of whether you choose the online or in-person format, we highly recommend you check out the facilitation tips we developed with our rural library partners.

- We developed “a day in the life of a rural engineer” videos that you can use in each session. Links for each video can be found here.

Learning Goals:

- Learn about the engineering design process.
- Engage in the engineering design process to develop and improve solutions.

Learning Objectives:

- Participants will construct a variety of 2D and 3D shapes using gumdrops and toothpicks, and explain why the triangle/pyramid is the strongest basic structural form.
- Participants will construct and test a tower against a vertical load (pencils) and a lateral load (simulated wind).
- Participants will improve their design by changing at least one feature, and explain what they changed.

Materials (for 1 caregiver/1 child):

- Session 1 package:
  - 25 toothpicks
  - 15 gumdrops
- All session package:
  - 1 masking tape, 1 pair of scissors, 1 measuring tape
- Bonus Items:
  - 5 straws
  - 5 popsicle sticks
  - 5 pipe cleaners
  - 10 rubber bands
- From home:
  - Recyclables: cardboard box, pencils, plastic container lid (to simulate wind) etc.
  - Markers/crayons
- List for purchasing each material and cost

  Note: Feel free to take out materials that are marked as optional if you want to reduce the total cost of the kit.

[Session curriculum]

Ignite [20 minutes]

Ignite Intro (1 min)

Section	Script
Welcome	***(Slide 1)*** Welcome to our very first session of Family Makers!
Share reminder and CHILD acronym (1 min)	***(Slide 2)*** This is a family-directed making activity, and we want to put the child at the center. So, parents, we encourage you to always help the child figure things out instead of solving the challenges for them. So, let's use the acronym CHILD to remember our guiding principles. [Read each acronym out loud using the script below. Feel free to change the examples if you think other prompts might be better.] C stands for Child chooses what to work on. Allow the child to choose the steps and directions they want to take during the discussions and making. If they are indecisive, try helping them make a choice but don't choose for them. E.g. So what is the next step you want to work on? Let's go with what you like best. What is your choice? H stands for Help your child by asking, not telling. Use questions to help prompt your child about making decisions. Don't give them a solution straightaway and try to help them come up with it by themselves. E.g. Can you try thinking of another way to build this? I stands for Inspire by letting your child lead. Let your child be the one to make decisions. Encourage and lead them so that they can make the decisions by themselves. E.g. What's your idea for making this more creative? How did you want to change it? L stands for Learn with patience to overcome frustrations. Try taking a step back. Let the children know it's ok that it is natural for things to fail or not work the way you expect. E.g. What made you angry? Let's take a step back. Should we take a mental break and think through this together? It's ok don't worry, we can try again. The best inventions came from people who kept going even when it was tough. Don't worry about the mistakes. They're just part of making something awesome.

	D stands for Discussion over direction. If your child is stuck, try to provide examples or suggestions on what to do. Try to help the child come up with the solution instead of directly pointing out what to do next. E.g. Do you remember some of the examples or suggestions the librarian shared earlier? How about using this material? What do you think?

Ignite Icebreaking Activity (10 min)

Section	**Script**
Icebreaking activity (3 min)	***(Slide 3)*** Let's start with an icebreaking activity. ***(Slide 4)*** Please introduce yourselves by sharing your names, what grade you are in, and which schools you go to or if you're homeschooled. Parents, please also share your names and anything you want to tell others about yourselves.
Treasure hunt (7 min)	***(Slide 5)*** To help us get to know each other a little better, we'll do a quick treasure hunt! Each participant will have 3 minutes to find something in their home that they really like—this could be a favorite toy, a book, a photo, or any object that holds special meaning. Once everyone has found their item, we'll take turns sharing what we found and explaining why it's important to us. I will share my item to show you how it's done. [Share your treasure hunt item to model how it is done.] Now, it's your turn. You will have 3 minutes, and 3 minutes start now! [Convene families after 3 minutes.] [Treasure Hunt conversations can be prompted using these questions: ● What is one special memory associated with this item? ● How does this item reflect something about yourself or your family? ● Why do you enjoy having this item in your life?]

Ignite Introduce the DQ and EiE (1 min)

Section	**Script**

Introduce the driving question (1 min)	***(Slide 6)*** Now, let's dive into our session. Today, we are focusing on: What is the engineering design process and how we can use it to build and improve solutions? ***(Slide 7)*** To get us started, let's watch a short video showing examples of what an engineering design process is and how you might engage in each stage. [Start the video at 0:33 and end at 3:25: https://www.youtube.com/watch?v=MFGg1calQ6k]

Ignite Connect (8 min)

Section	**Script**
Show video (3 min)	***(Slide 8)*** [Show the engineering design process slide: ask-imagine-plan-create-improve.] Let's take a proper look into the engineering design process. As you just watched, it's a process that engineers use to develop products and solutions that improve our lives. This process is iterative, meaning you can repeat these steps as many times as you need and that multiple stages can be used at the same time. Sometimes, when people are working on their ideas, they start changing things even before they reach the improve stage. Also, it's okay to fail and make mistakes because that's part of how engineers work! This is called "productive failure." It means engineers keep testing and redesigning until they find the best solution.
Share personal examples (5 min)	***(Slide 9)*** Do you have any examples of engaging in ask, imagine, plan, create, and improve in your daily lives? What examples come to your mind? Can we have 1-2 people share? ***(Slide 10)*** [If no one answers, consider asking these prompt questions: • Have you ever built something with LEGO or made a fort with pillows and blankets? What steps did you take? If you remember, you probably had to ask questions to figure out what to build, create and make improvements.

	Note: Feel free to tweak or adapt this section to introduce other examples that might connect better with what children know in your local context. For instance, making a costume or sewing a patch could highlight the "design-test-improve" cycle in the engineering design process. Adjusting an animal feeder or setting up garden irrigation could also highlight how we identify a problem, test solutions, and make adjustments in daily life.

Make [50 minutes]

Make Intro (1 min)

Section	Script
Introduce the making challenge	***(Slide 11)*** Now, we are going to act like engineers by doing a simple challenge that involves constructing a tower using gumdrops and toothpicks!
Share reminders	***(Slide 12)*** Also, please remember our acronym, CHILD and try to encourage your child to take the lead as the engineer/designer.

Make Simple Challenge (12 min)

Section	Script
Engage families in 2D shape challenge (5 min)	***(Slide 13)*** We are going to create some simple shapes using gumdrops and toothpicks. You will have 1 min for each shape. Now, let's get the materials out. Can you find them? Give me a thumbs up if you got them. [Move on when everyone found the materials.] First, let's create a triangle using gumdrops and toothpicks. And…your time starts now! [Timer set for 1 minute. Let families know when time is up. If you observed that families are not needing the full minute, feel free to shorten the challenge to 30 seconds instead.] I think everyone figured it out pretty fast. So, instead of 1 minute, we are going to try to make it within 30 seconds. Are you ready? The next shape is a rectangle.

	[Timer set for 1 minute or 30 seconds depending on your situation.] Ok, looks pretty good! The last shape is a square. Do you know the difference between a square and a rectangle? Square has four sides that are equal while a rectangle can have two sides longer and two sides shorter. So, timer starts now! [Timer set for 1 minute or 30 seconds depending on your situation.] What you've just built are 2D shapes—the triangle, rectangle, and square. These shapes are flat and make up the foundation of all structures.
Engage families in 3D shape challenge (3 min)	***(Slide 14)*** Now that we've explored 2D shapes, let's move on to 3D shapes! We'll start by building a pyramid. Do you know what a pyramid looks like? A pyramid is a shape with a flat base and triangular sides that come to a point at the top. Again, you have 1 minute. And…1 minute starts now! [Timer set for 1 minute or 30 seconds depending on your situation. While families are building, say: As you build them, think about how these shapes differ from the 2D ones.] Great! Everyone was able to create their pyramids. Now, can we try creating a cube? A cube is a 3D shape with six square faces, and all its sides are the same length. [Timer set for 1 minute or 30 seconds depending on your situation.]
Explain the strongest structure (4 min)	***(Slide 15)*** We've built various shapes so far. These shapes are key structures when we build our towers, which is what we are going to do next. But, when you build something big and tall like a tower, what combinations of shapes might help? Many believe triangles are the strongest shapes because they distribute weight evenly. Let's watch this video to see why. [Play the video. Stop it at 2:46: https://www.youtube.com/watch?v=mBHJtWbsiaA] Can someone tell me why triangles are the strongest shapes? [Wait for one person to answer.]

	Pyramids are the strongest shapes because their pointy tops and sloping sides help spread out weight. When you push down on a pyramid, the force is balanced along the sides, making it less likely to collapse. Cubes, with their flat tops, can easily fall over if too much weight is added as you saw in the video. So, pyramids are like strong superheroes of shapes! As we move onto building our tower, remember different structures that provide stability. Also, remember that combining shapes can make structures even stronger and more useful. For example, if we add squares to a pyramid, the pyramid's strong shape could help support the weight above, while the square base provides a flat, stable area for sitting. This way, we get the best of both worlds: the strength of the pyramid and the practicality of the square. It's like teamwork for shapes!

Make Complex Challenge (37 min)

Section	Script
Build a tower to hold 10 pencils (4 min)	***(Slide 16)*** Ready to move on? Next, we're going to be making several towers. ***(Slide 17)*** Your first challenge is to build a tower that can hold 10 pencils without collapsing. We will each spend about 3 minutes, then stop to share what we've made. If it turns out your tower cannot hold 10 pencils, that's ok. The excitement comes from trying, not necessarily completing, so don't worry if you can't quite complete the challenge. We are going to try again. Failure is part of engineering. So, ready? Your 3 minutes start now! [Timer set for 3 minutes. Show these on the slide: ● How can you make sure your tower can carry the weight? ● What shapes or structures can help distribute weight evenly?]
Test (4 min)	***(Slide 18)*** Once your tower is built, let's test if it can hold 10 pencils. On my count, we will add the pencils one at a time together. When we do this, let's all make sure your camera is pointing at the tower so everyone can see if your tower can hold the pencils. Take a picture if you can.

	Ready? Ok, on my count…1, 2, 3….10! Does the tower hold up the weight, or does it collapse? Why? Take a look at some of these questions, and I would like to ask if anyone would like to share your thoughts on any of these questions. [Show these on the slide: ● What strategies did you use to make sure your tower could hold the pencils? ● What shapes did you use that helped keep everything balanced? ● Did anyone have a tricky moment while building? How did you fix it?]
Improve (4 min)	***(Slide 19)*** Based on some of these ideas you just shared, try to make improvements to your tower. If you couldn't quite get all 10 pencils to hold, try changing the structure a bit. If you were able to hold 10 pencils last time, challenge yourself to add more pencils or pens you have in your house. See how many you can hold! We will spend about 3 minutes to make improvements. [Provide 3 minutes.] Can anyone share what kind of improvement you made? [Have one person share.] Ok, we are going to do another challenge, but first please take a picture of your tower.
Build the highest tower (5 min)	***(Slide 20)*** Now that we've explored a bit, let's take on another challenge which is going to be a little more complicated. Let's build the highest tower using only 10 toothpicks and gumdrops. Your goal is to make it as tall as possible while ensuring it remains stable and doesn't collapse with only 10 toothpicks and gumdrops. We will let you brainstorm how you want to build this with your parent first. Plan out how you might like to do it. [Have families talk and plan for about 2 minutes. Show these: ● How can you make the tower tall without it tipping over? ● What shapes can help support the height?]

	Now, we will spend 3 minutes to build the highest tower. I will let you know when time is up. [Let families know it's time to stop after 3 minutes.] Ok, we are going to do another challenge, but first please take a picture of your tower.
Test (3 min)	***(Slide 21)*** Now you have a prototype for your tallest tower, measure the height of your tower with the ruler/measuring tape from the "For all sessions" kit. Take a picture and also write down its height. [Provide time for families to measure the height and take a picture.]
Material hunt (4 min)	***(Slide 22)*** Ok, your next challenge is to build a tower that can withstand a simulated tornado. We'll simulate the tornado by shaking or blowing on the surface of the tower to see if it remains standing. To do this, we are going to do a material hunt to find a really big book, bigger the better, or you could grab a lid to a plastic container. We will use them to create a gust of wind as tornado. As you go on this material hunt, also grab any items that can help make your tower stronger, more stable, or taller. Find anything you think might help with your design. We'll have 3 minutes to do this. Your 3 minutes start now!
Build a tower that withstands a tornado (5 min)	***(Slide 23)*** Ok, did everyone find something that they can use to simulate tornado as well as other items that can help with your design? Give me a thumbs up so we can move on. Ok, again, we will each spend about 3 minutes, then stop to share what we've made. Your 3 minutes start now! [Timer set for 3 minutes. Show these on the slide: • How can you make the base of your tower strong enough to withstand shaking? • What shapes or materials can add stability?]

Test (3 min)	***(Slide 24)*** Once your tower is built, it's time to test it! Shake the surface or blow air on the tower by swishing the book or the plastic container lid you previously grabbed to simulate a tornado. Take a picture if you can. [Allow time for families to test it out. Ask families to change the angle of their camera if you cannot see their testing.] Did the tower stay standing? If it fell, what do you think you could change to improve its stability? Any volunteers to share your ideas? [Show these on the slide: ● What combination of shapes did you use? Did it work? Why or Why not?] ● If your tower fell during the tornado test, what changes do you think could help it stand stronger next time?]
Improve (5 min)	***(Slide 25)*** Based on your ideas, let's make some improvements. Talk to your parent what you might like to change, and why. We will come back after 3 minutes to share out your improvements. [Show these on the slide: ● What part of your tower felt the weakest? Did your tower sway or wobble during the test? How can you reinforce that area? ● Did the base of your tower provide enough support? ● How can you change the shape of your tower to help it stand up against the wind? ● Can you think of any material in the house that could make your tower stronger?] [Give families time to discuss for 3 minutes] Can anyone share what kind of improvement they made? [Have a few people share.] ***(Slide 26)*** What you made looks amazing! ***(Slide 27)*** It's time to take pictures of what you made.

Reflect [10 minutes]

Reflect Family Conversation (5 min)

Section	Script
Family talk (2 min)	***(Slide 28)*** Now, let's take some time to reflect on what we did today. ***(Slide 29)*** We talked about the engineering design process, and we actually acted like engineers by engaging in asking, imagining, planning, creating, testing, and improving. Think about how you used each of these steps today while building your toothpick tower. I'm going to ask parents to take the lead in asking the following questions to your child while we are muted. [Ask families to mute and discuss the following questions: • Did you enjoy building these toothpick towers? • Do you feel like we engaged in the engineering design process (ask-imagine-plan-create-test-improve)? How? • How did testing your tower make you feel? What did you learn from that experience? • Do you want to learn more about engineering? Why or why not?]
Share (3 min)	***(Slide 30)*** Now, let's come together as a whole group. I want to ask all families to share at least one question they discussed during the family discussion. Any volunteers to go first? [Ask families to share.]

Reflect Wrap Up (5 min)

Section	Script
Wrap up	***(Slide 31)***

(3 min)	I hope you enjoyed this activity. ***(Slide 32)*** Just like real engineers, you planned, created, tested, and made improvements today. Engineering is about solving problems and trying things out! In daily life, we solve small challenges like organizing a room or carrying heavy bags by thinking of solutions, testing them, and trying again if needed. Engineering takes this further by designing and building things, considering forces, materials, and factors like weather. ***(Slide 33)*** For example, engineers calculate how much weight a bridge can hold and how it withstands strong winds. Both everyday problem-solving and engineering are essential and fun. Today, you experienced how engineers tackle challenges by testing and improving their designs. Great job! ***(Slide 34)*** Civil and construction engineers do a lot of testing to keep things safe and strong! Civil engineers work on buildings, bridges, and roads. They test materials like concrete and steel to see which ones work best. Construction engineers take these plans and make sure everything is built correctly. They help choose the right tools and make sure workers stay safe. Together, they make sure everything they build is strong and safe for people to use!
Share our engineer video (2 min)	***(Slide 35)*** Before we wrap up our session, I'd like to show you a video. In our final session, we'll have a special guest engineer who will share what they do. So here's a video of all the engineers who might be able to come join us during our last session. [Play the video: https://www.youtube.com/watch?v=leCag8Q7C9k]
End session	***(Slide 36)*** I hope you had a great time building and learning today, and I hope to see you next time. ***(Slide 37)*** To learn more, we also have a deepen activity that you can do at home without us. It will be available in the booklet.