Contents

4   Introduction
6   Confront Failure
26  Thought Provoking Questions
46  Applying Engineering Methods
64  Finding Teachable Moments
82  Curiosity Machine:
      Empowering Parents Through Science
To all the moms and dads out there,

I’m excited to share my story about parenting in a world filled with technology, distractions and lots of opportunities. I have three beautiful kids, each with their own amazing talents and challenges. My oldest son Mike is a junior in high school. He is a talented football player and wants to play in college, but he has a hard time keeping his grades up. Brittany is in middle school. I’m sure she will be the CEO of a major company one day, but sometimes I worry that she spends all of her time studying, and there’s no time left for being a kid. My youngest, Jackson, is my baby boy. He is full of life and curiosity.

I’m a single mom, but my mother stays with us to help out. I work two jobs to make ends meet, and sometimes I think that if I had gone to college, I would be in a better position. I know I can’t dwell on the past, so I just focus on creating opportunities for my kids. I want them to go to college, and I want them to explore the world, even if they just leave our neighborhood to pursue other opportunities.

Over the past year, I stepped out of my comfort zone and started learning how to be a better parent. I started attending school meetings, taking classes at church and reading stories online about successful parenting. Everything I have learned has changed our lives in a positive way.

It’s my hope that in sharing my experiences and what I’ve learned this year, other parents who feel like I did will be able to apply some of those lessons to their lives.

I know your time is limited so I have created this book as a way for you to learn at your own pace. So as long as you regularly...
take time to read and complete the exercises, you will be on your way to reaping all the benefits. Ok...let’s get started!

With love,
Alisha
First, I’d like to share an experience I had with my daughter, Brittany, who was struggling in algebra. She’s always been a good student and learning had always come easy to her up to this point, so suddenly struggling in a class was extremely difficult for her. She started saying things like, “I hate math” and “I can’t do it” which were very out of character. I quickly became concerned she would give up and lose interest in math altogether. I never went to college, but I know that giving up on math would limit her opportunities for college. So I was very worried...
I wanted to change her attitude, so I started saying more encouraging things to her, like complimenting her on how well she was doing in other subjects. But then she would respond with, “yeah, but I’m failing math so who cares.” Since compliments didn’t work I tried telling her stories about some of the challenges I had faced as a single mother. I shared stories of going to school at night while raising three young kids or my car breaking down and having to save up for a new one. The stories seemed to help a little, but it was hard for her to relate these stories to her situation.

Finally, I started reminding her about the challenges she had overcome in the past. In elementary school, Brittany was a really shy kid. She would not talk to the other kids and would end up being alone during recess and lunch. Everything changed in fourth grade when we made a plan. Brittany would start saying ‘hi’ to a different kid everyday. Slowly this turned into small conversations with her classmates and other kids in the hall. Eventually, a group of girls invited Brittany to sit with them at lunch. After that, she slowly started opening up to other kids and is still friends with some of the girls that invited her to lunch. She had to face her fear of talking to someone she didn’t know! When I reminded Brittany of how far she’s come, she became hopeful of overcoming this challenge as well.

Later that week, I asked her teacher what I could do to help Brittany. She told me there were a couple of workshops the school’s Parent Center was offering in the evenings that would be helpful for me. I attended one that same night. The topic discussed was “growth mindset”. Honestly, I had no clue what that meant but I figured I had nothing to lose. I listened carefully and took many notes. Afterwards, I felt much more prepared to help Brittany through her difficult situation and in a matter of days she was back on track! Here is what I learned at the workshop, and what I did at home.
The strategy that I learned is called “fostering a growth mindset.” In other words, believing that with dedication and hard work, you can get better at anything.

**Summary of Alisha’s Experience**

With a growth mindset, we can persevere through failure until we succeed. With a fixed mindset, we either fail or succeed, and don’t attempt to improve.

**Growth mindset**
- Believes intelligence can be developed
- Embraces challenge
- Persists to try again
- Learns from criticism

**Fixed mindset**
- Believes people are born intelligent or not
- Avoids challenge
- Gives up easily
- Sees criticism as bad

Based on research by Carol Dweck, Ph.D.
The opposite of a growth mindset is a fixed mindset. A fixed mindset is a belief that you can’t do something no matter how hard you try because you weren’t born with a specific characteristic or skill (like intelligence). People with fixed mindsets tend to think that everyone is born with specific intelligence or abilities and that those abilities can’t change.

With a growth mindset, opportunities are endless. A child will be more confident when faced with problems or challenges because she knows that with hard work she can succeed in anything. She will also start to see failures or mistakes as a part of the learning journey instead of as proof she isn’t good at something. This makes it easier for her to persevere through failures and mistakes.

Learning about growth mindsets and how to help my children develop them was super exciting for me. Toward the end of the workshop, the presenter handed out some worksheets. He said these would help us put into practice what we had learned that night. When I got home I started on this first activity.

Circle the statements that best describe the thoughts that come to you in the following situations.

**When trying something new:**

- What if I fail? I will be a failure.
- Can I really do this?
- People will laugh at me for thinking I could do this.
- If I don’t try, I won’t fail.
- I am not sure if I could achieve that now but I believe I can learn with time and effort.
- Even the most successful people have faced failure.
- If I don’t try, I have already failed. What pride is there in that?

**When facing a setback or failure:**

- This would have been easier if I were smarter.
- Now that I’ve failed, everyone will know I am not good at this.
- My talent can be developed more with practice and time. That is the key to getting better at this.
When facing criticism:

• It was not my fault! I was never smart enough to succeed at this!

• I’m never going to be able to do this so I should not even bother.

• I’ve failed, and now I know what I can improve.

After this exercise do you lean more towards a fixed mindset or growth mindset?

I learned so much about myself from this activity that I decided to do it again with Brittany. She really enjoyed it and we laughed about the kinds of “fixed” statements that we make to ourselves when faced with certain challenges. She even mentioned how she frequently says to herself, “this would be so easy if I were smarter,” when doing her algebra homework. I asked her if she wanted to learn more about growth mindsets and how to overcome challenges. She said “yes!” So, the following week we completed another activity together, too.
It is common to have both a fixed mindset about one thing and a growth mindset about another. For example, your child may have a growth mindset about becoming a great baseball player, but a fixed mindset about making better grades. They know they can only become a great baseball player with practice, but might not realize that school work is the same. It needs practice!

The more you are able to recognize what type of mindset your child has regarding different things, the more likely you will be able to help encourage a growth mindset.

For one week, start by listening to your child to see where they have a fixed mindset and a growth mindset. Pay attention to what you say and other kids, teachers and parents say. Write down what you observe in the table below.

<table>
<thead>
<tr>
<th>What</th>
<th>What was said?</th>
<th>Was it a fixed or growth mindset?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex. Algebra</td>
<td>I can’t do this!</td>
<td>Fixed</td>
</tr>
</tbody>
</table>

Activity 2 (by PERTS¹)

https://www.perts.net/

Confront Failure
On a Sunday afternoon, we both sat down to read the different statements we had heard in our home. We documented statements we each had made, and even wrote down statements we heard from Grandma that struck us as being related to "growth" and "fixed" mindsets. We used the following chart to help us change our "fixed" statements:

<table>
<thead>
<tr>
<th>Situation</th>
<th>You Can Say This:</th>
<th>Avoid Saying This:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finding solutions</td>
<td>“I liked that way you used different types of strategies in this project until you finally made it!”</td>
<td>“Wow! You did well with that problem in one try. You are so smart!”</td>
</tr>
<tr>
<td>Completing projects</td>
<td>“That was long and tough but you dedicated yourself to finish it and you did it. Great job!”</td>
<td>“See, I told you this was going to be easy for you. You are very talented!”</td>
</tr>
<tr>
<td>Succeeding with little effort</td>
<td>“That was way too easy for you. Let’s try something a little bit more challenging so you can learn something new.”</td>
<td>“Great job! You got an “A” without any effort.”</td>
</tr>
<tr>
<td>Working hard and failing</td>
<td>“I like the effort you put in. Let’s work together a little more and let’s try to understand what you do not yet understand.”</td>
<td>“Some people are simply not good at math or science. Don’t worry about it.”</td>
</tr>
</tbody>
</table>
I sat down with Grandma to explain what I had learned about mindsets and how we need to be mindful about the comments we make around the kids. She was more interested once she made the connection that our comments would help Brittany change her perspective when facing difficult tasks. I asked her if she could do me the favor of jotting down statements that imply a person is born smart and those that imply that a person can learn and improve their level of understanding. I did the same in this section:

<table>
<thead>
<tr>
<th>My growth mindset statements</th>
<th>My fixed mindset statements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This helped me get a better understanding of my own mindset and also Grandma’s, but the next activity helped me put into practice everything I had learned.
Activity 3

Try all three actions over the next week and write down how you feel afterwards.

1. Do something that makes you feel uncomfortable or that you were afraid to do before. (Examples: Try Zumba, make a difficult meal, speak to your child’s teacher.)

2. The next time you make a mistake, stop and reflect on it. What can you learn from it? Talk about it with your child. Even if it is a small thing like "the dinner turned out too salty", what can you do differently and how can you make it taste better?

3. Ask for feedback from your boss or family member in an area you don’t feel confident in. What did you learn from their feedback?
After completing this activity, I felt more equipped to help Brittany overcome her struggle with algebra. I asked her how she was feeling about the subject and she expressed she was still struggling a bit but that the conversations we had been having about “growth mindsets” have really helped her not to give up. She said, “Mom, I am beginning to realize I can do this. I am doing well in other things it’s just some subjects are easier for me to understand than others.” I told her, “Baby, I am so proud of you already because of all the effort you are putting into learning this. Keep it up and soon it will become easy for you.” At that moment, I realized that all I had to do was remind her that if she works hard at something, she can get positive results. I just need to help her remember that one thing!

Brittany started to be more patient with her math homework and she reached out to her teacher for help. It has been great to see her solve her own problems and feel confident again.
At 15, Michael Jordan tried out for the varsity basketball team at his high school and did not make it. Instead of giving up, he played on the junior varsity team, learned how to dunk and spent a year working on his game. "Whenever I was working out and got tired and figured I ought to stop, I’d close my eyes and see that list in the locker room without my name on it," said Jordan. "That usually got me going again." Jordan won six NBA championships, five MVP titles, and scored 32,292 points during his career. He is considered one the best basketball players of all time.

"I have missed more than 9,000 shots in my career. I have lost almost 300 games. On 26 occasions I have been entrusted to take the game winning shot, and I missed. I have failed over and over and over again in my life. And that is why I succeed.”

— Michael Jordan
Family Science Activity

Try this design challenge from Curiosity Machine with your family to continue developing a growth mindset!

Design Challenge: Build a Communication Network

Plan and build a network to send communication signals in multiple directions to multiple people.

Suggested Materials
Estimated cost: Free to $5

Recommended

• Cups of different sizes
• String, twine, or fishing line
• Scissors and tape

Optional

• Paper clips
• Push pins
• Cardboard
• Washers or nuts

Testing Station

• At least 2 people and a quiet space

Confront Failure
Inspiration

Communication networks send and receive signals to spread information. People can access and send out information through many types of connections. Before you create a plan for your network, research and choose at least two communication networks for inspiration. Here are some types networks to check out:

In a wheel network, all information is given and received by a person in the middle.

In circle network, there is no central person. Instead, communication flows equally from one person to another, with no start or end.

Chain networks have a clear start and end point.

In star networks, every person can communicate with each other.

What type of network do you think the internet is? What type of network do you think would work best for a sports team?

Explore sound.

Sound waves move differently depending on the material they are moving through—air, solids, and water will spread sound differently. As you plan your communication network, keep in mind these terms:

Vibration: A vibrating object creates sound waves. Your ears will interpret the vibration as sound.
Aplitude: The height or amplitude of the wave changes with the volume of the sound. Tall waves are louder, small waves are quieter. More energy is needed for tall waves than small waves.

Frequency: The speed or frequency of a wave determines whether it is a high pitch sound or a low pitch sound. There are some sound frequencies that humans can’t hear!

Plan

In this design challenge, you are going to make a network that multiple people can use to communicate. You’ll do this by creating your own communication network, linking together your materials in a way that helps people to share information by sound over multiple pathways across a distance. Think about the different ways and types of materials you can use to connect people in a communication network.

Apply your research! How can you use your materials in new ways? Remember, sound waves will travel through things like cardboard, string, and metal differently. Create at least 2 plans that explore how you can send messages by adding these different materials.

If you need help getting started, you can find video and more resources for this design challenge at curiositymachine.org/challenges/114

Build

Choose the plan you think will work best to build your Communication Network. Building can be one of the most frustrating parts of a design challenge. If your child gets frustrated, remember to pause and remind them that the challenge is difficult, but that together you can do it if you keep trying.
Test

Gather family and friends to test your communication network.

- Observe your prototype’s performance by looking and listening and writing down your impressions.
- Measure its performance. Measurements can be height, distance, repetitions, temperature, volume—anything that you can write down as a number!

Remember, growth mindset means learning from not just success, but failure as well! If something doesn’t work like you think it should, try to figure out why.

Redesign

Apply the growth mindset and think about the observations you gathered from testing your prototype. Here are some tips:

- Make sure your string is stretched taut, otherwise the energy from the sound wave will not travel very far.
- Experiment with different materials. Some transmit sound waves better than others.
- Make your network directional by using materials to muffle sounds.

Even if your prototype worked well, think about what was hard for you to get right. What did you have to tinker with? What would you improve if you were building another communication network?
Reflect

• Every person has both growth and fixed mindsets. What part of this design challenge did you have a fixed mindset about? How did you persevere to continue learning?

• Frustration is inevitable when doing hard things. How will you encourage your child to move past frustration in other daily tasks, like completing homework?

• How do the materials you used affect the way the sound wave travels?

• How could you redesign your network to work over a longer distance?

• Can you think of a way to add two networks together?
Summary

I hope learning about "growth" and "fixed" mindset was as helpful to you as it was to me. In summary, here is what we learned in this chapter:

• People with growth mindsets see intelligence as something that they can develop with effort.

• People with fixed mindsets see intelligence as something that cannot change.

• To foster a growth mindset, make statements that acknowledge work and dedication instead of outcome or result.

• You can change your mindset from "fixed" to "growth" by being open to new things and not being afraid to fail.

• Remember, failure is only one step toward achieving success.
Chapter 2

Thought Provoking Questions
I try to attend PTA meetings and other school events, but I work two jobs. Last Monday I traded shifts with my coworker, so I was able to attend a parent-teacher conference at my son Jackson’s school. It’s hard to believe my youngest started fifth grade! To my surprise, Jackson’s teacher said that he sometimes gets into arguments with another student, Mason. This really surprised me because Jackson and Mason are friends, and Mason has been to our house to hang out.
When his teacher told me that Jackson and Mason were sent to the principal’s office for disrupting class last week, I got upset. She thought I knew because they sent him home with a letter for my signature. I never received it, but my mother helps me with the kids when I work and study. I decided to ask her about the letter when I got home.

My mother said that Jackson never gave her a letter, but she did notice a change in his attitude. He has been short with her and spending more time in his room. I asked why she didn’t tell me, and she simply replied, "I handled it." My mother is old school, so I’m sure "handling it" meant a lecture!

I sat Jackson down to see what was happening between him and Mason and asked why he did not give the letter to Grandma or me. He tried to act like it was not a big deal and eventually became upset because I kept asking questions. His responses were always short, "no, mom," "yes, mom," "ok, mom." Frustrated, I decided to email the teacher.

His teacher said that sometimes kids don’t want to talk about things with parents because they are embarrassed or afraid of getting in trouble. His teacher gently recommended that I change how I ask questions. Instead of asking questions that can be answered with one or two words, I should ask "open-ended questions" that would require an explanation or discussion. If we want to have meaningful conversations with our kids we have to allow them to think before they speak and give them an opportunity to fully express themselves.
I learned that the way I ask questions changes the type of response I get. I could try asking more Open-Ended Questions to get Jackson to tell me more about what was wrong.

Closed Questions can be answered with a simple yes or no. They are good for quick, short answers rather than deep discussions, and do not encourage children to include details or think critically to respond. For example:

*Do you have homework?*

*Did you have a good day at school?*

*Did you have trouble with math class today?*

Open-Ended Questions have unlimited possible answers. They are perfect when you want someone to think critically about their answer, provide details, or share their thought process. These questions encourage children to organize their thoughts and ideas to giving an answer. For example:

*What is your homework for today?*

*What was your favorite thing you did today?*

*What could you do differently to do better in math class?*
During dinner that night I decided to try a different approach to my usual questions. Most nights when I ask, "Did you have a good day at school today?" I end up getting a straight yes and nothing else. This time I decided to ask, "What was your day like?" Brittany was the first to respond. She has no problem with talking my ear off about the drama in her pre-teen life! I tried to channel that energy and switch the conversation over to Jackson by asking him, "What did you and Mason do today?" Although he hesitated at first, Jackson eventually told me he embarrassed Mason in front of their friends.

That evening, I continued asking open-ended questions in order to work through the problem and eventually Jackson found a solution. It didn't take long for their friendship to recover, and I also learned a lesson that I will never forget.

Asking questions that encourage conversation can help you understand the problem your child is facing and can even prevent situations from getting worse. After changing my approach to asking open-ended questions for the past few weeks, I feel like I know my kids better. We talk more about how their days went, what makes them happy and sad, and our dinner conversations are a lot more interesting! I thanked Jackson's teacher for the help and told her about the success I had with her advice. I suggested she do a workshop about asking better questions and she did! She focused on open-ended questions and how they are a great way to help your child reflect on their day or a problem they are facing.
The Power of Open-Ended Questions

The first time I talked to my son, he only responded to my questions with one or two words like, "no, mom" and "ok, mom." That’s because I was using closed questions. Closed questions are really only useful if you need a quick or fact-based answer, like asking if they fed the dog or how old they are. If you want to have a deeper conversation with your child, try to avoid closed questions.

Learning about the different types of questions and how they can affect my conversations was eye-opening: I never realized how much of a difference changing a couple of words could make! She encouraged us to use open-ended questions at home and shared some of the benefits she learned from teacher and educational psychologist, Dr. Jane M. Healy in her book *Is Your Bed Still There When You Close the Door?*

Asking children open-ended questions helps to:

- Improve brain function and language skills
- Develop mental skills that lead to academic success
- Lay the groundwork for mathematical and scientific reasoning as well as for reading and writing
- Teach children to express themselves effectively
- Help children analyze and process information
- Develop creativity and problem solving abilities

It’s not an easy change to make, but Jackson’s teacher gave us a few exercises to practice at home.
In the 1950’s, Barbara Walters became a pioneer in the news industry, developing an interview technique that led to her promotion to co-anchor of the evening news—a first for a woman in the United States. She is known for her ability to ask questions in a way that encourages people to think deeply about their responses, and sometimes even reveal personal struggles. When asked about her interviewing technique, she stresses the importance of listening closely to what the other person says, and following up by asking a question like, "What did you mean by that?"

“I try to ask questions that people are not asked all the time, that make them think, that tell me something I haven’t heard before."

– Barbara Walters
Activity 1

Look at the following scenarios and write how you would normally ask the questions when talking to your children. Then try to identify whether your questions are closed or open-ended. Remember, there is no right or wrong question. This activity is designed to help you determine if you are using the best questions for each scenario.

**Scenario 1**
You want to ask you child about their day.
Your question:

**Scenario 2**
Your child is having difficulty with homework.
Your question:

**Scenario 3**
You want to encourage your child to find a solution to a problem they are facing.
Your question:

**Scenario 4**
You want to learn more about your child’s interests.
Your question:
Let’s look at the main characteristics of open-ended questions. You can identify open-ended questions by the following characteristics:

- Requires child to pause and reflect before answering
- Encourages child to share based on personal feelings, opinions, and ideas
- Requires the child to think critically by actively reflecting and structuring their answer mentally before responding
- Allows the response to be as important to the conversation as the question
- Usually starts with why, how, describe, tell me about, what do you think about...

Based on these characteristics, what sort of questions were you asking for each scenario?

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open-Ended</td>
<td>Open-Ended</td>
</tr>
<tr>
<td>Closed</td>
<td>Closed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario 2</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open-Ended</td>
<td>Open-Ended</td>
</tr>
<tr>
<td>Closed</td>
<td>Closed</td>
</tr>
</tbody>
</table>

If any of your questions were closed questions, you can make them open-ended by:

- Changing the first word of the question
- Asking yourself the question to ensure there is more than one way of answering it
- Not implying the answer in your question. For example, “Do you think it was a bad idea to argue with Mason?”

With practice, I’ve gotten better at asking my children open-ended questions.
The exercise helped me realize how often I use the wrong type of questions when trying to start a conversation with my kids, but it’s often because I’m just so busy. Work, kids, chores; I’m stuck in a daily routine that makes me feel like a robot! But now I feel better prepared to make small changes and have more meaningful conversations. Especially with my kids, I want to know everything that’s going on with them! I know there’s some things they just won’t tell me, but I want them to feel comfortable talking to me and I can start by asking questions that will encourage them to talk more.

During the parent workshop, I learned how important it is for us as parents to 1) allow enough time for our children to reply and 2) be ok with whatever response they give us. Similar to what we learned about growth mindset, the main goal of asking open-ended questions is not to get the right answer from our child but to give them an opportunity to exercise their critical thinking skills.

Professor Mary Budd Rowe researched *wait time* in classrooms. Wait time is the amount of silent time given after a question is asked. Experts suggest giving a child about 3-5 seconds so they can formulate their response in their head before verbalizing it.

**Benefits of wait time:**

- The accuracy of their responses increase.
- The number of their “I don’t know” decreases.
- Failure to respond decreases
- Confidence increases
Activity 2

To practice your ability to provide your child with enough wait-time ask your child the following open-ended questions one by one and try to wait at least five seconds for them to form a response:

- What was your favorite part of the day and why?
- What did you do during lunchtime?
- I want to learn about what you did in science class. Can you explain it to me?
- What are you most excited to do tomorrow?

Remember, the goal of this exercise is for you to practice your ability to give your child enough time to respond, not for you to evaluate your child’s response or get antsy that they are not engaging with you the way you want them to.
I loved doing this activity with my kids. At first, our conversations were a little awkward because we were all staring at each other silently, but eventually we got used to having longer conversations and came to really enjoy them. By providing my kids with a little more time to think, we ended up having much more meaningful conversations. I’ve had a little more trouble getting my oldest son, Mike, on board with my new open-ended questions. He was so used to grunting being an acceptable answer to my questions. I’ve been trying to be patient with him because I do want to know more about what’s going on with his life. Sometimes it takes one or two follow-up questions to get him talking. I have to ask why and how and I make my questions as open as possible. When all else fails I gear my questions towards football and that always works! It takes a lot of creativity to be a parent.

The teacher told us that listening is work because it requires our full attention. Many times we are coming up with responses in our head, instead of listening to what is being said to us. I was certainly guilty of doing that. She said that young people might not call us out for not listening but they pick up on the cues and this can affect them in a negative way. I wanted to make sure I didn’t make my children feel that I was not listening to them. As a rule of thumb, I decided that anytime I ask my children an open-ended question I would not judge them for their response or try to correct them, but rather listen to what they wanted to share with me.

Simply by listening, you’re giving your child an opportunity to share based on their own experiences, personal feelings, opinions, and ideas. Not only are they thinking critically about their answer, but you’re letting your child know that what they have to say is important. This next activity is really easy. I tried it with my kids and I think we ended up having the longest conversation we’ve ever had!
Activity 3

When you’re talking to your kids, repeat a part of what they just said. If you like, you can build on their response by restating something they said as a question. For example:

Mom  “What was your favorite part of the day?”

Child  “Seeing my paper plane fly.”

Mom  “Why was seeing your plane fly so special?”

This activity made me think more critically, and my kids were happier, too! Asking questions this way shows that you’re paying attention and thinking about what they are telling you. Believe it or not, kids care about these things! They want to know that what they have to say is important.

I’m learning more and more that I can have a big impact on my kids’ education. Even the smallest effort from me can make a difference. I now try to use open-ended questions whenever I can.
While you’re building with your children, ask them questions that really get them to think critically about the work that they’re doing. Challenge them to try new things and guide them to find a solutions on their own.

**Design Challenge: Build a Vertical Jumping Machine**

Make a machine that can jump up more than 3 feet.

**Suggested Materials**

Estimated cost: up to $2

**Recommended**

- Cups of different sizes
- Rubber bands of different sizes and strengths
- Scissors
- Tape

**Optional**

- Hole puncher

**Testing Station**

- Yard stick for measuring height
Inspiration

Biomechanics explores how different systems in the body work together to perform a task. In order to understand the movements of the human body, we must look at how each individual part of the body is able to move and how forces make them move. A movement that might seem simple, like jumping, is actually a very complicated combination of different muscles, bones and joints working together.

Before you make a plan for your vertical jumping machine, research different mammals (this includes humans!) and how high they can jump. Why do you think some mammals are able to jump higher than others?

Keep in mind these terms as you get inspired for your design:

**Force:** A force is something that can make an object move.

**Potential Energy:** Energy that is stored in an object and waiting to be used.

**Kinetic Energy:** Potential energy converted into movement.

**Elasticity:** Elasticity is how stretchy an object is and depends on the materials. The more an object is stretched, the more elastic potential energy is stored.
Plan

In this design challenge, you are going to make a machine that is able to jump at least three feet in the air. You’ll do this by taking advantage of the potential energy that can be stored in elastic bands.

Take time to ask your child what you will engineer and be sure they understands the materials!

While you plan, consider the different materials you have and how they can have an impact on your design. Here are some open-ended questions you can use to get your child thinking:

• What materials can you use that will act like the muscles used when a person jumps?

• What object will be the “body” that makes the jump?

• Weight is a force that needs to be overcome in order to jump. How will this information change your design?

Have your child stretch and release different sizes of rubber bands to see if they notice a difference in how far they go. Ask them why they think some rubber bands are able to go further than others.

After they sketch out their designs and decide on what materials they want to use, they can move on to the building!

If you need help getting started, you can find video and an inspiration gallery for this design challenge by creating a free account at curiositymachine.org/challenges/102

Thought Provoking Questions
**Build**

Talk to your children about their design and help them build a few models. It’s okay if they still don’t understand how to make their design jump more than 3 ft. Remember, it’s important to keep a growth mindset and there’s nothing wrong with failing!

**Test**

Check to see if your vertical jumping machine can jump at least three feet in the air. If it does, great! If it doesn’t, make sure you record if it is able to get off the table or how far it can go. Also, note the direction it is going. Encourage your child to record any other observations they think are interesting.

**Redesign**

No one expects the design to be perfect the first time! Have your child choose at least one thing to improve. If their design was able to jump three feet in the air, encourage them to make their design better by finding a way to make it jump higher or changing the direction in which it is going. Here are some tips for improving:

- You may want to make more than two design to compare which design works the best
- When you let go of the prototype, make sure you can move your hands away as quickly as possible to prevent blocking the jump
- Using a solid surface for testing and rigid materials to build the prototype can increase the force on the object.
Reflection

Ask your child these questions to see what they’ve learned:

• Did your prototype generate enough force to jump 3 feet? Why or why not?

• How would you redesign in order to make it jump 6 feet?

• If you could have any material on the planet for your prototype, what would you choose and why?

• What part of this design challenge did you have a fixed mindset attitude about? How did you persevere to continue learning?
Since I started using more open-ended questions with my children, our conversations have improved a lot. I can tell they know that I really do care about their thoughts! Here’s a few quick reminders I use:

- Closed questions can often be answered with a simple yes or no.
- Open-ended questions have unlimited possible answers and encourage children to organize their thoughts and ideas.
- A goal of asking open-ended questions is to give kids an opportunity to exercise their critical thinking skills.
- We should give a child about 3-5 seconds of wait-time so they can formulate their response in their head before verbalizing it.
- Remember, it’s not about getting right answers but about improving communication!
Chapter 3

Applying Engineering Methods
I’ve really been enjoying these parent workshops our school has been offering because they have helped me understand my kids better. Brittany has always been too hard on herself. She wants to be the best at everything and used to get so upset and embarrassed when she earned anything less than an “A” in class. Now she’s learning with genuine curiosity and not just to earn a grade. Jackson has been opening up more to me and tells me when he’s having problems at school. He knows I want to help him work through problems instead of punishing him for failures. Even Mike has started to talk to me more. It’s usually still about football, but I’ll take what I can get!
The next workshop was about the Engineering Design Process. The teachers got together to go over this topic with us because the kids would need to follow it for their upcoming science fair projects. Usually when the kids have projects, they wait until the last minute and we’re running around looking for materials to put together. We usually hope for the best and pray that we get it right the first time. No room for mistakes when you’re in a time crunch!

However, in the workshop I learned that this wasn’t the best method. I guess I always knew there was a more efficient way to get a project (or anything really) done but this had worked for us in the past. The teachers explained that all of the students must use the Engineering Design Process if they wanted to enter their projects into the science fair and they must document their progress under each step: Inspiration, Plan, Build, Test, Redesign, and Reflect. By following the Engineering Design Process, the kids would learn to solve science and engineering problems just like real scientists and engineers.

Over the next month, I worked with Brittany and Jackson to complete their science projects and follow the Engineering Design Process (or “EDP”). We loved using the process because it allowed us to break up the large projects into smaller parts. Brittany and Jackson felt accomplished each time they were able to check off a step of the EDP after they detailed their progress. We were able to finish on time and stress free, which is not something that used to happen often in our household. The teachers explained to us that the EDP can be applied to many different situations, so hopefully from now on we’re able to use this tool to be more efficient, not only with school work but also with any challenge that may come up.
The engineering design process has 6 basic steps:

**Inspiration**: Find a problem that needs to be solved and look at the world around you for possible solutions to that problem.

**Plan**: Document how you plan to solve the problem. This can be drawings of designs, a list of materials, timeline, and even a budget!

**Build**: Begin to build your design/solution according to the plan.

**Test**: Test the design to see if it does what it is supposed to do. *Testing is another form of the exploring that very young children do, like dropping food from a table or tickling a sibling to see what happens.*

**Redesign**: Make changes to the design based on what you learned in testing. Often it takes a few tries to get a design to work well, and students need to be encouraged to persevere and learn from failures.

**Reflect**: Lastly, take some time to look back at what you learned during this entire process. What was accomplished, and how does it change how other problems could be solved?
This process is different from "trial and error", which is trying different things without a plan until the solution is found. This is what our family used to do when completing a project. We would go out and buy all different kinds of materials and start building right away. We would get frustrated and stuck when nothing worked because no one had a clear plan. We weren’t trying to understand why something worked or didn’t, we were just trying to get to the end result.

<table>
<thead>
<tr>
<th>Trial and Error</th>
<th>Engineering Design Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little to no thought is given to the project. There isn't a clear plan or direction. Potential issues were not predicted and avoided.</td>
<td>Much thought is given to the project before starting. A plan is created and potential issues can be foreseen and avoided.</td>
</tr>
<tr>
<td>Often wastes time an resources.</td>
<td>Saves time and resources.</td>
</tr>
<tr>
<td>Some scientists use trial and error when they are trying to learn as much as they can instead of answer a specific question.</td>
<td>Scientists and engineers use this method when facing and solving challenges.</td>
</tr>
</tbody>
</table>
As parents, we can encourage our kids to use the Engineering Design Process to solve any problem they might encounter in day to day life. The teacher encouraged us to use the engineering design process next time we take on a new personal project so we can model this process for our children. She also explained how using this process helps to build problem solving skills and self-efficacy. I was surprised to learn this, and very excited to start using this process at home.

Here’s one way I started using the EDP at home – trying out a new recipe!

**Inspiration:** Look through different recipes, photos of meals, or different versions of the same recipe to decide what you’ll make.

**Plan:** Write out your recipe. List your ingredients and steps. Collect any materials (ingredients!) you’ll need.

**Build:** Start cooking!

**Test:** Taste the food to check if any ingredient is missing or if flavors need to be adjusted.

**Redesign:** Add or remove ingredients from your recipe to improve taste. Keep notes for the next time you cook the recipe.

**Reflect:** Ask yourself what you would have done differently. Ask for feedback.
At age 15 Henry Ford fixed the watches of friends and neighbors so many times that he gained the reputation of a watch repairman. He held many jobs, including machinist and steam engine serviceman, before becoming an engineer in 1891. He was interested in gasoline engines and experimented in creating a low cost, high quality car. After many failed attempts, he eventually successfully raced a 26-horsepower automobile and formed the Henry Ford Company. Ford is credited with developing and manufacturing the first car that many middle class Americans could afford. In doing so, Ford converted the automobile from an expensive curiosity into a practical tool that would have a huge impact on the world.

"Failure is simply the opportunity to begin again, this time more intelligently."

-Henry Ford
Activity 1

Try the Engineering Design Process at home, and record notes on each step here. You can use any problem that you find yourself having to solve, whether it’s a science project, a meal, or home maintenance.

Inspiration

Plan

Build

Test

Redesign

Reflect
I never realized how much effort goes into cooking without realizing it—Well, the effort Grandma puts into cooking. I always see her looking through cookbooks at night to find what she wants to make the next day. Then she makes her grocery list to buy ingredients in the morning. When she starts cooking she usually tastes it and adds her own twists and secret ingredients. Then when we eat, we all tell her how amazing it is! We even have her tell us what she puts in it. I’ve started to call out the steps of the engineering design process when Grandma is cooking or whenever I spot one of the kids using the steps without realizing. It’s interesting to see how often it can be applied to our everyday lives. And it has so many benefits!

Using the Engineering Design Process helps to:

• Better organize homework and projects
• Lower frustration levels
• Develop problem solving skills
• Develop critical thinking skills
• Save time and resources spent solving a problem
Imagine your child’s birthday is coming up and you want to host a party for them. This might not seem like a great opportunity to use the Engineering Design Process, but it is! What would you do for each step to make the party a success? Take a couple minutes to think through each of these steps and write what you would do.

**Inspiration:** What are your child’s interests? Decide on a theme:

---

**Plan:** List ideas, recipes, and materials. Make a Checklist:

- [ ] ____________________________  - [ ] ____________________________
- [ ] ____________________________  - [ ] ____________________________
- [ ] ____________________________  - [ ] ____________________________
- [ ] ____________________________  - [ ] ____________________________
- [ ] ____________________________  - [ ] ____________________________

**Build:** Check off items in your list as you put them together.

**Test:** Does everything work the way that you planned?

---

**Redesign:** Are any adjustments needed? What are they?

---

**Reflect:** Think back. What can you do better next time?
This workshop was so simple, but it helped me identify when I use the engineering design process without even realizing it. The hard part is remembering to document the process when we apply it to projects like school work and fixing up the house. Sometimes I get so caught up in wanting to finish something quickly that I forget to plan, and end up wasting time.

I’ve really been trying to encourage Mike to use the Engineering Design Process. He has this old bike he’s been fixing up, but he hasn’t really made any progress. I sat with him the other day to take a step back and learn more about what he was actually trying to do. It turns out that all he needed to do was replace the chain but he had been so insistent on fixing the old one. We watched some videos of people replacing bike chains at home, and then came up with a plan for what he needed to buy for his specific model of bike. We ordered the materials and now he’s ready to take a stab at it. I think he feels a lot better about his plan. He used to always come back into the house so frustrated and the whole family can see an improvement in his teenage angst!
Now that you have learned a couple techniques for applying the Engineering Design Process to real life situations, it is time to practice! In this section, you and your family will have the opportunity to learn a few physics concepts and build a design challenge.

**Design Challenge: Balance a Dinosaur**

Build a dinosaur at least 6” tall that can balance on two legs using counterbalances.

**Suggested Materials**

Estimated cost: Free to $2

**Recommended**

- Cardboard or toilet paper tubes
- Pipe cleaners, popsicle sticks, or straws
- Paper clips
- Tape
- Pennies or small weights
- Ruler
Inspiration

Some dinosaurs were bipedal, meaning they could stand on two legs. Humans are also bipedal, but unlike dinosaurs our bodies remain straight when we walk. Before you create a plan for your dinosaur, research different types of dinosaurs you may want to build. A few you can look up are T. rex, Allosaurus, and Fruitadens. Be sure to:

- Observe each dinosaur’s body posture
- Describe the angle of the legs to the body and how the weight is carried
- Describe the upper body and tail and note if you think they help the dinosaur to distribute the weight?

Apply your research! What type of dinosaur do you want to build? How do you think your dinosaur will be able to balance with a tail? Here are a few concepts to keep in mind while building:

**Weight** is a force caused by the gravity of our planet acting on a body or object.

**Center of Mass** (Center of Gravity) is the point where all the weight of an object can be balanced.

A **counterbalance** helps to distribute weight in an object to help keep it from tipping over.
Plan

Remember to check in with your child to see if they know what they’re building! Help them sketch out a design and choose materials. A dinosaur’s tail acts as a counterbalance to their upper body. The bigger a dinosaur’s upper body and head, the larger the tail will need to be to balance! They should:

• Label materials
• Label where they plan to place counterweights
• Circle 2 parts of the prototype that will counterbalance each other

If you need help getting started, you can find video and an inspiration gallery for this design challenge by creating a free account at curiositymachine.org/challenges/70

Build

Remember the challenge is to build a dinosaur at least 6 inches tall that can balance on two legs using counterbalances. Notice that dinosaurs are not completely upright. Usually the front or the back seem lighter or heavier. Are you ready? Let’s get started!

Test

Chances are your child will have to do a lot of testing for this design challenge as they figure out how best to balance their dinosaur on two legs.

• Does it work the same every time?
• Does it work if it looks different?
Make a plan to test your prototype by thinking of questions in each category below.

Describe (Qualitative data)
For example, describe whether adding weight helps the dinosaur balance.

Measure (Quantitative data)
For example, how long can the dinosaur stand before it falls?

How can you use the results from testing?

• Identify one part that needs to be improved and design a way to fix it.

• Consider what is causing the balanced or unbalanced forces and keep or change that part of the design.

Redesign

Apply your growth mindset and help your child power through the frustration. Now that they’ve identified what works and what doesn’t, ask them open-ended questions to help them troubleshoot and solve any issues they might be having. Try these tips for common problems:

• Try adding more weight or moving the counterbalance.

• Make sure your dinosaur’s feet are flat on the table.
Reflection

Now that we’ve built the best design we could, reflect back on the concepts you had to apply and answer the following questions together:

• How could you change your design to be twice as tall and still stand upright?

• If you made the dinosaur’s head twice as large, how could you change the design to still stand upright?

• What modern animals also have body parts that act as counterweights?

You’ll notice that the Build, Test, and Redesign steps look similar and may even overlap in some respects. The steps seem to overlap because we don’t even notice we’re following this process! Think about when you’re cooking and you add all of your ingredients and finally taste what you’re making. You notice it needs something and you fix it. You just tested and redesigned, probably without realizing that’s what you were doing! For the design challenges, however, it’s important to keep these steps separate. We want our kids to be able to problem solve, and that requires being able to clearly identify a problem, think of a possible solution, plan, and put that solution in place and evaluate whether or not the solution works.
I feel like we have been much more productive with our time ever since we started using the Engineering Design Process. Being able to break apart a challenge and tackle it one step at a time has even reduced our stress levels! Here are a few things to remember when trying to use the Engineering Design Process at home:

- The Engineering Design Process has six steps: Inspiration, Planning, Building, Testing, Redesigning, and Reflection
- The trial and error method is when you try different things without a plan until you find a solution
- The EDP helps to better organize your project and develop problem solving and critical thinking skills
- The EDP can be applied to any type of project, it doesn’t have to be school related!
Chapter 4

Finding Teachable Moments
Applying Engineering Methods

The engineering design process was such a fun, new topic for us. We’ve been using it with school work and around the house. It has actually become like a game for us. Just the other day Brittany told me she wanted to make a scrapbook as a birthday present for her friend, and I asked what her inspiration was and how she was planning the project. How would she place the pictures? Would they tell a story? How many pictures could she fit?
Now, it may seem silly to go through these steps for a birthday present but I wanted her to think about what she was doing so she wouldn’t show up at the store to buy supplies without an idea for what she wanted! So far these topics have really been coming together, so I was excited for the next workshop.

To my surprise, the next concept was more science heavy. I had some reservations when I showed up and the words “energy, force, and Newton’s laws” were written on the board. The teacher explained that there was nothing to be worried about since it wasn’t about understanding the science like a scientist, but about understanding how the same science ideas are seen again and again in nature and in the things humans build. It helps to explain simple science concepts at home. She called it creating teachable moments. She went on to say that science is all around us, whether we realise it or not. She gave us four examples of science topics that we experience everyday and how we can point them out to our kids to share how interesting and exciting the natural world is. She explained that these concepts are constantly popping up and that by simplifying understanding them we will be one step ahead in understanding how the world works!
Energy

In school, children learn that the definition of energy is the power to do work. In everyday life we think of energy as being strong and active, able to do work both physical (lift the grocery bags) and mental (remember the grocery list). And the faster you move or think, the more energy you have!

My kids are active, running around and creating noise as they go about their business. My mother often says to the kids that she wishes she had as much energy as they do! But, while energy can’t be shared from one person to another by wishing, energy can be moved from one object to another—like when the kids slam the door and pictures on the wall start shaking or vibrating. The pictures get energy from the push of the door slamming. There are many different types of energy that are part of our daily lives. Any time something moves, makes a sound, or lights up there is energy!

If an object is moving, it has kinetic energy. Water flowing, wind blowing, and a car driving are all good examples of kinetic energy. Even electricity and heat are types of kinetic energy!

An object creating light has electromagnetic energy. Lightbulbs turning on, microwaves, radios, and even the sun’s light are examples of electromagnetic energy.

Objects that aren’t moving at all have energy, too! An object that is not moving can have potential energy, or stored energy. For example, a roller coaster at the top of a ramp has potential energy, since it has the potential to fall back down and create kinetic energy.

Throughout the next day, Jackson and I made a game of finding examples of energy in the house and even at the grocery store. It was fun, and a great opportunity for me to practice finding teachable moments!
Activity 1

Find as many examples as you can of movement, heat, light, or even things that might move or change but haven’t yet! Then, try to figure out what type of energy you found.

<table>
<thead>
<tr>
<th>Energy Clue</th>
<th>Type of Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>ex: Apple falls off a table</td>
<td>ex: Potential and Kinetic</td>
</tr>
</tbody>
</table>

Curiosity Machine
Forces

Next, we learned about forces. A force is a push or pull on an object. That seems simple, but there are many ideas being combined into one. As the teacher said, it helps to take them apart and recognize each separately.

1. A force can move an object that's sitting still.

2. A force can act on an object that does not move.

3. A force takes place when two objects interact and stops when the objects stop interacting.

4. Forces can occur between objects that are close together or far apart.

5. One object may have more than one force acting on it.

Now, in the drawing below, work with your child to draw arrows that show push and pull forces.
When more than one force acts on the same object at the same time, understanding how the object will react gets a little tricky. But, these can be understood more easily when we think about how the forces balance out.

**Balanced forces** are equal and opposite, so the object does not move as a result. For example, you can hold a crayon between your two pointer fingers if they are opposite each other and press equally.

**Unbalanced forces** are unequal and/or not opposite. When forces are unbalanced, they cause movement! For example, if you move one of your pointer fingers upward on the crayon, it will spin and probably fall. The forces holding it in place are no longer balanced.
There are also many different types of forces. The teacher explained a few, but also told us there are many more! The main thing to remember is that they are all pushes and pulls. Think back on the engineering design challenges that you’ve been doing. What different ways have you created pushes or pulls on objects? What different ways has kinetic energy (or motion) been created?

For example, when an object flies through the air, it experiences 4 types of forces:

- **Weight** is the pull of gravity on an object. The more mass an object has, the more pull it will feel, and the more it will weigh.

- **Lift** is the opposite of weight. On an airplane, the shape or the wings create an upward push as they move through the air.

- Engines create **thrust**, so pushing the plane forward through the air.

- **Drag** is created by the air behind the airplane pulling backward. I think of this as similar to the swirling wake of a fast boat.
Sonia Sotomayor is the first Latinx Justice appointed to the Supreme Court of the United States. She grew up connected to her roots in Puerto Rican communities in the Bronx, raised only by her mother after her father passed away when she was nine years old. Her mother always valued education and encouraged Sonia and her brother learn. Even though she attend private Catholic schools in the Bronx, when she attended Princeton University she felt as though she didn’t stack up to the other students. She felt she had to work twice as hard to gain the skills, knowledge and confidence that she was lacking. Sonia worked as a lawyer in the public and private sectors before being nominated as a district judge in New York. She credits her success to the incredible opportunities she’s had.

"Until we get equality in education, we won’t have an equal society."

–Sonia Sotomayor
Newton’s Laws

In 1687, the scientist Sir Isaac Newton published a book that laid the foundation of our understanding of motion and forces today. The ideas within the book were such a significant advancement, they have remained as central concepts to science ever since.

Newton’s First Law of Motion is where the popular phrases, “an object in motion stays in motion” comes from. The full law of motion is that an object will either stay at rest or in motion until a force acts on it. For example, a ball that is sitting on the floor won’t move until some force pushes or pulls it. Or, when you throw a ball, the ball will keep moving until the air it’s moving through slows it down enough that it stops.

Newton’s Second Law of Motion is all about the amount of force it takes to move different objects. So, an object that doesn’t weigh much like a pencil can be moved very easily with only a little bit of force, but a heavier object like a brick will need more force to be moved.

Newton’s Third Law of Motion is based on his discovery that every action has an equal but opposite reaction. So, if you fill a balloon with air and let it go, the air will push out of the balloon in one direction, and the balloon will fly in the opposite direction.

The ideas that Newton put into these three laws explain motion. This is especially important for things that move, like cars, people, or planets. However, they are also necessary for things that are not moving. When you sit down to rest on the sofa after a long day, you want to stay at rest!
It’s interesting to see all of the different forces that are happening around us, and fun to practice finding examples. It’s one more thing that I can help my kids understand!

The other day we went to the grocery store and Jackson wanted to push the cart around since he thinks he’s a big kid now. We were walking around finding the groceries on our list. We had a long list, since we try not to stop at the store more than once a week. About halfway through, Jackson started slowing down and it looked like he was struggling to move the cart. He told me he was tired and no longer wanted to push the cart around. I asked him why he thought he was struggling and he said that it was too heavy. I asked why he thought it was heavy, remembering to phrase it as an open-ended question. This lead us to talk about Newton’s Second Law of Motion and how you need more force to move heavier objects and as we added more groceries to the cart and the mass changed, he needed to exert more force to move the cart to keep it moving at the same speed. Eventually I let him take a break and used it as another learning experience to explain how strong moms are.
Let’s see how engineers practice using these forces when they’re building! Remember to keep practicing the engineering design process and ask open ended questions.

**Design Challenge: Engineer an Air-Powered Spinning Machine**

Build an air-powered spinning machine inspired by Boeing CST-100 Starliner.

**Suggested Materials**

Estimated cost: Free to $2

**Recommended**

- Cardboard
- Straws
- Paper clips
- Scissors and tape
- Skewers or dowels
- Balloons
- Paper cups
Inspiration

The CST-100 is a revolutionary new spacecraft, that makes it safe and easy to transport astronauts up to the International Space Station (ISS). It is the first commercially reusable, human rated spacecraft, meaning that its crew capsule can be used to perform multiple missions in space. How they get to the International Space Station though, involves precise maneuvering and a strong understanding of physics. You would use orbital maneuvering thrusters, which are all around the vehicle, and the maneuvering thrusters are kind of like the steering wheel on your vehicle. Those thrusters are pushing gas in one direction to cause the spaceship to move in another direction or the opposite direction.

We’ve already learned a few concepts in the chapter, but these will be helpful to keep in mind when building:

**Thrust:** a push force which moves something forward. The CST-100 has a propulsion system with 24 thrusters to help it move around in space! It changes the direction of the thrusters to steer through space.

**Wheel and axle:** simple machines in which motion is transferred from one place to another. The axle holds the wheel in place while allowing it to spin freely.
Plan

For this design challenge we’re going to build something that can spin, using thrusters. So there will be some kind of force that will help our design move. Work with your child to explore the materials and decide which item will do the job.

Encourage your child to build more than one plan. In life we ever hardly get things right the first time, so let’s plan our backup in case things don’t workout. The obvious choice for thrusters might be the balloons, but think about other ways to force air to move!

If you need help getting started, you can find video and an inspiration gallery for this design challenge by creating a free account at curiositymachine.org/challenges/70

Build

Remember, we’re building an air-powered spinning machine. We don’t say how the air should make it spin, so encourage your child to think outside the box! They might even choose to use some other materials they find around the house. They can also start with their design that they don’t think will work as well. This will help them understand WHY it’s not functioning the way they want it to and can lead to an even better redesign!

Test

Now it’s time to see if our machine can spin! We want to pay attention to the way our machine is rotating so here are some things to think about when recording data:

- The speed of something that spins around an axis is measured in revolutions per second (RPS) or degrees per second (°/s) - (one rotation/revolution = 360°).
• In the perfect machine, a spinning wheel would never stop spinning. In the real world, friction due to the wheel rubbing on the axle slows the spinning. What can prevent this?

Make a plan to test your prototype by thinking of questions in each category below.

**Describe (Qualitative data)**
For example, *describe whether the machine spins freely or not.*

**Measure (Quantitative data)**
For example, *how many times does the machine spin in 10 seconds?*

**Redesign**
Now that we know what works and doesn’t work, let’s look at at least one thing we would like to change. Think about what makes your machine spin and if there are ways to improve it.

• Are there ways to strengthen the supporting base structure so the machine doesn’t topple?

• How can the axle be improved to reduce friction and spin more easily?

• How can the thrusters be improved to create more motion?
Reflection

At this point, you and your child should have a design you’re both happy with. If not, it’s time to keep Building-Testing-Redesigning! Let’s reflect back on the concepts we talked about and figure out what we learned through the building process. Ask your child the following questions:

• How did the direction of the air release effect the spinning?

• How does changing the direction of the thrusters alter the rotation of the prototype?

• How does increasing or decreasing the amount of air used change the speed of the thruster?

• Did you go back to the ideas you collected during the inspiration or look for new ideas to improve your machine?

• What is easy or hard to learn from the testing to make or revise your plan?
I never realized how simple some of these Physics concepts were. It helps you explain why so many things around you are as they are. Usually you don’t question why a cup falls to the ground, but understanding the science behind these mundane tasks helps to see the bigger picture. Here are some points from the workshop to keep in mind when explaining science at home:

• Energy can either be stored or active (potential or kinetic).

• A Force is a push or pull applied to an object.

• Balanced forces are equal and opposite so the object can not move.

• Unbalanced forces are unequal and/or not opposite, so that the biggest force will cause an object to move.

• There are four forces that need to be generated in order to achieve flight: lift, drag, thrust, and gravity.
Chapter 5

Curiosity Machine: Empowering Parents Through Science
The teachable moments workshop was eye-opening! I never realized how much science we interact with every day. Just the other day we were at the park and a flock of birds flew by. I asked Jackson if he knew how birds fly. I didn’t quite know the answer myself, but I wanted to see what he came up with. His first answer was that a bird’s wings make them fly, but then I asked him why penguins can’t fly. We started discussing the size and shape of wings and how that might make a difference. We spent a great afternoon talking about science while also being outdoors. Win-win!
The last session of the semester was on how to create an effective learning environment at home. Kids spend most of their time at home, so it makes sense for parents to continue encouraging learning after school. We were each asked to share observations, tips, and ideas for supporting our kids to learn at home. This list of tips is the result:

**Healthy Body, Healthy Brain**

- Have a healthy snack ready when your child gets home from school, even if she asks for junk food instead. It’s hard to think on an empty stomach, and sweet snacks or junk food can be saved as rewards later in the evening.

- Make sure your child goes to bed on time so she can focus during the school day, and still have energy afterward for family projects.

**Make a Design Challenge Calendar**

- Create a calendar to schedule family activities and post it where the whole family can see. Make sure to schedule some design challenge time!

- Celebrate by marking the calendar with stickers when you finish a design challenge. This helps visually mark progress and activities ahead.

**Prepare for Design Challenges**

- Before starting the design challenge, get familiar with the problem you needed to solve and review any science concepts that are unfamiliar.

- Gather some basic materials needed for the challenge.

- Think of a few open-ended questions to ask during the design challenge.
Prepare Your Child for the Challenge

• Explain the challenge to your child and ask a few questions to make sure she understands:
  “What is the challenge or problem we are trying to solve?”
  “What are we building? What materials should we use?”
  “What science are we going to learn about?”

• As you plan the design, ask your child to explain the plan and why she thinks it will work.

Showcase Your Design

• Whether or not your designs work, celebrate your designs to your family and friends.

• Ask your child to explain her design with questions such as:
  “What worked?”
  “What was difficult?”
  “Why?”

• Remember growth mindsets! Let your child know it’s okay if their design did not come out perfect the first time. There is always room to redesign.
Invite More People

• Make an event out of learning! Invite your child’s schoolmates or friends to build together.

• Ask parents if they would like to help you put the event together by bringing materials or snacks for the kids.

This exercise was really beneficial to me. The fact that I had an opportunity to share my ideas and experiences and learn from others was empowering. I also learned how to build more learning activities into my family’s home life and expand my children’s learning opportunities.
The principal joined us to talk about why these workshops are so important. She shared some statistics about STEM careers with us. STEM stands for Science, Technology, Engineering, and Mathematics—as you might know, there aren’t enough people qualified to hold these sorts of jobs to actually fill all the open jobs.

I learned that there are many different types of STEM careers. It’s not just mechanical and structural engineers—there are data scientists, website developers, medical scientists and so many other positions that fall into STEM fields! The need for people qualified for STEM careers is supposed to increase a lot over the next few years. Plus, jobs in these fields provide some of the highest incomes, but even so, people don’t pursue these careers.

The leaders started to wrap up the session by telling us about project-based learning. Project-based learning is a teaching method where students learn specific concepts and skills by by working on investigating and solving one problem for an extended period of time. These types of activities are the best tools to help children become more confident and self-motivated. The Curiosity Machine design challenges we’ve been doing during the workshops are project-based learning activities.

The workshop leaders especially wanted to give us these tools to help our children continue learning at home. Students only spend 20% of their days in school, so why have the learning stop there? Unlike teachers, parents can give children more time, more resources, and even a safe space to fail. School can be stressful because grades are the ultimate goal. No one wants to fail or be held back.
A problem. Even though STEM careers will form the backbone of future employment\(^1\) and have some of the highest earnings\(^2\),…

![Projected Percentage Increases in STEM Jobs: 2010-2020](image)

Students, especially girls, do not choose STEM fields. Furthermore, less than 3% of African American and Hispanic students go into STEM\(^3\), even though they account for 40% of all k-12 students.

![Percentage of Students Who Choose STEM Careers](image)

\(^1\) US Department of Education

\(^2\) Federal STEM Education 5 Year Strategic Plan

\(^3\) President’s Council of Advisors on Science and Technology
In 1992, Mae Jemison became the first African-American woman to travel into space. She had always been curious and first began understanding science by studying the nature around her. Her parents were always supportive of her love of science and would help by creating teachable moments from everyday experiences, like getting an infection from a splinter. She graduated high school at the age of 16 and left her home to attend Stanford University. She recalls being treated as if she didn’t belong, even by professors. Nevertheless, she obtained degrees in Chemical Engineering and Afro-American Studies and went on to Cornell University to become a medical doctor, practicing in the US and abroad before she was accepted to NASA’s astronaut program in 1987. Jemison continues to advocate in favor of science education and getting minority students interested in science.

“What we find is that if you have a goal that is very, very far out, and you approach it in little steps, you start to get there faster. Your mind opens up to the possibilities.”

- Mae Jemison
At home, children have more freedom to try things and really explore their creativity. This really motivated me to start doing more projects at home. As parents, we don’t need a lesson plan or curriculum. We just need to have fun and give our kids an opportunity to try new things.
Family Science Activity

Look back at all the design challenges we’ve built so far. Do you notice how some of the science and engineering ideas keep repeating? Even if your child sees a problem that looks unfamiliar, remind them to look for things that come up a lot and think about what they’ve learned before that connects to the new problem.

Practice makes understanding an idea or getting better at a skill easier. Keep encouraging and modeling the learning behavior you want your child to learn from. Take short times during the day to review schoolwork or try fun activities that make learning feel more like play.

Design Challenge: Build a Robotic Arm

Design a robotic arm that is 12 inches long and can move a marble, a straw, and a washer from the table into a cup.

Suggested Materials

Estimated cost: Free to $5

Recommended

• Paper cups of different sizes
• Skewers, dowels, popsicle sticks, and/or straws
• String
• Scissors and tape
• Rubberbands

Optional
• Paperclips
• Marbles
• Washers

Testing Station
• Different shaped items, like marbles and straws, to test if your Robotic Arm can pick up different objects

Inspiration

Robots help people do a lot of different things. Before you create a plan for your Robotic Arm, research different types of robots and think about the different ways they help humans. As you research, see if you can find examples of robots used in manufacturing, healthcare, households, or even outer space!

Apply your research! How can you make a robot pick things up? How will it move?
As you start thinking about how to make your Robotic Arm, keep in mind these terms:

**Deflection:** how much something bends when a weight is put on one end of it. You need to think about this so your robotic arm doesn’t break when you try to lift something heavy!

**Fulcrum:** the point of rotation, or the point where something spins around. Think about where to place the fulcrum so when you apply force, your prototype can open and close.

**Grabbing mechanism:** Think carefully about the different objects you are trying to pick up and make sure the grabbing mechanism will work for them without dropping, squishing, or breaking them.

**Plan**

Take time to ask your child what they will engineer and be sure she understands the materials!

Now you are ready to plan your Robotic Arm. Consider your materials and how you want your prototype to move.

Draw your idea, label with arrows and words the grabbing mechanism and pivot points!

If you need help getting started, you can find video and an inspiration gallery for this design challenge by creating a free account at curiositymachine.org/challenges/86

**Build**
Talk with your child about her plan. It’s okay to build a few different grabbing mechanisms, testing the materials and how everything fits together.

As you continue to create a learning environment, try to ask some open ended questions while assembling your prototype.

Test

Together, check if your Robotic Arm can pick up at least 3 different objects. Be sure to record what needs fixed and how you think you can improve.

Redesign

Pick at least one thing to improve. Think about Growth Mindset--redesign is an important part of learning and improving! Some Robotic Arm improvements to consider are:

- Create a grabbing mechanism that can gently pick up an egg as well as a piece of paper.
- Strengthen your prototype so it shows less deflection.
- Make it easier to hold and use.

Reflection
Now is a great time to ask more open ended questions! Here are a few to get you started:

- How do you think this Robotic Arm could be used in the real world?
- What was the hardest part of building this prototype?
- Every person has both growth and fixed mindsets. What part of this design challenge did you have a fixed mindset attitude about? How did you persevere to continue learning?
I’ve really enjoyed the workshops I’ve been attending and I hope you’ve found some of these topics beneficial as well. It’s not always easy to start doing new things. I’ve been able to adopt a few practices and change them to work for my kids. There’s no right way to support our kids, but they’ll always appreciate our efforts! I’ve definitely noticed a shift in Mike, Brittany, and Jackson’s interactions. Everyone used to go their separate ways after school, but now we spend more time together and talk instead of just looking at screens. I hope you continue learning and trying activities with your kids. Remember you can revisit any of these activities in the workbook anytime or find more design challenges to build on www.curiositymachine.org

Keep having fun!