ACTIVITY 4: Structures



It's all about stability!

When building a structure, it is important to start with a strong and stable base.

TARGET AGE GROUP

Preschool-K

TIME

60-90 minutes

PREPARATION

Review the RTL Activities introduction for tips and suggestions before implementation.



Design Time (4:26 – 8:42)

The Cat in the Hat Knows A Lot About That!

Pause the video and reflect on the ideas being explored by Cat in the Hat and his friends, Nick and Sally. Here are some places you might pause:

- □ After Sally says, "Why are these three things still standing and everything else fell over?" (~7:22), ask the kids:
 - Did the robot bump everything over?
 - Do you think the robot can bump some things over but can't bump other things over? Why do you think that?
- $\hfill\square$ At the conclusion, ask:
 - How did Nick get the robot turned off?
 - What change did Sally and Nick make to the design of their tower? Why did they make that change?
 - Did the robot knock over the tower with the large base? Why do you think the robot was unable to knock over the tower with the new design?

*Recommend clip, full episode can be used

Let's investigate how different surface materials affect how far an object moves.

EXPLORE

Children will use the engineering design process to create a structure with a sturdy base.

Materials:

- □ Building materials:
 - Jumbo craft sticks
 - Plastic 3 oz. cups
 - Tin foil
 - Pipe cleaners
- □ The Cat in the Hat Engineering Design Process Graphic
- □ Paper
- Pencil
- □ Optional: Yard stick, measuring tape, ruler or non-standard form of measurement (i.e. The Cat in the Hat measuring hat)

INSTRUCTIONS

Review the Engineering Design Process:

- □ As a large group discuss the Engineering Design Process Graphic.
 - Explain that engineers use the Engineering Design Process as a way to solve problems.
 - Once engineers figure out the problem or what they are trying to create, they use their imagination and knowledge about how things work to make a plan, build their design, test it out and improve it.
- □ Ask kids, "Tell me about a time when you had a problem and how you solved it."

1. BUILD A TOWER:

- Tell your kids, Cat in the Hat has a real problem and needs their help.
 He is trying to build a tower, but he can't get it quite right.
- □ Remind kids of what they learned from Cat in the Hat about the base of the structure.
- □ Allow kids to work independently or in groups of two or three to build their own. Encourage them to use their engineering skills to imagine and plan, create, test and make improvements to their tower.
- □ Engage the children in short conversations about their plan as they build their tower. Questions could include:
 - Tell me about your structure?
 - How did you decide to start with that base?
 - Is your base strong enough to support how tall you want your tower?
 - ▶ I noticed that your tower fell over. Tell me how you are going to improve it.
- □ Allow kids to share their work.
- □ Optional: Children can measure their tower using provided measurement tool(s).

MORE WAYS TO PLAY:

- \Box Build the tallest tower in 5 minutes with the same materials.
- □ Build a structure using only one cup as the base.
- □ Add small wooden cubes to the materials list, and ave children build a structure with only one cube as the base.
- □ Create a structure that appears to defy gravity and is a feat of balance.
- □ Using wooden clothespins, small binder clips, and jumbo craft sticks, build a structure that:
 - Supports the most amount of weight.
 - Is the tallest structure.
 - Is the tallest structure with the fewest clothespins.

READ

□ Read *Iggy Peck*, *Architect* by Andrea Beaty using the following discussion prompts:

□ Before reading show the cover of the book as you read the title, author and illustrator, then ask the kids:

- What is an architect? (a person who designs buildings)
- ▶ What is the boy on the cover doing?
- What do you think the lady on the cover is thinking?
- □ As you read, ask:
 - ▶ Why do you think Miss Lila Greer dislikes architecture?
 - ▶ How do you think Iggy feels about being in Miss Lila Greer's 2nd grade class?
- \Box After the reading, ask:
 - Were Iggy's parents supportive of his interest in building things?
 - How did things change in Miss Greer's class after she crossed the bridge the children had built?
 - What are some of the materials lggy used in his creations?

Other book suggestions:

Rosie Revere, Engineer by Andrea Beaty Most Magnificent Thing by Ashley Spires The Three Billy Goats Gruff by Stephen Carpenter Twenty-One Elephants and Still Standing by April Jones Prince

PLAY

Hamster Run

In this game, available on pbskids.org, children use the Engineering Design Process to build, test and redesign a structure to help the hamsters reach food!

Engaging kids in conversation during digital play encourages learning.

- □ Ask:
 - > Did you always get the solution right on the first try in the game?
- □ If no, ask:
 - What did you do on your next try?
 - What kinds of things did

SHARE

Send the parent letter on the next page home with kids to encourage at-home conversations with families about this activity.

Hello Families:

Today we used our engineering skills to learn about structures with Cat in the Hat. We discovered that structures need a strong and stable base, so they don't fall over.

To find out more about what your kid learned, you can ask:

- > Tell me about your structure you built today?
- > Tell me about the base of your tower?
- Why did you decide to start with that base?
- Was your base strong enough to support how tall you wanted your tower?
- Did your tower fall over? Tell me how you improved your tower to help it stand up?

We also had the opportunity to read together *Iggy Peck*, *Architect* by Andrea Beaty. Have your child retell the story to you.

Here are some related books to look for at the library:

Rosie Revere, Engineer by Andrea Beaty

Most Magnificent Thing by Ashley Spires

The Three Billy Goats Gruff by Stephen Carpenter

Twenty-One Elephants and Still Standing by April Jones Prince

Tune into your local PBS station and visit pbskids.org online for more opportunities to learn, watch and play together with your family. Watching videos and playing games with your kids encourages social interactions, bonding and learning.

You can also access PBS KIDS content free in PBS KIDS Video app and the PBS KIDS Games app.



Resources to Support Structure Activities

Get kids thinking and exploring like scientists and engineers using this collection of **structures** resources from Ready to Learn PBS KIDS. Providing young children the opportunity to participate in simple, PBS KIDS-inspired investigations and engineering challenges is a great way to support developing inquiry and engineering skills and practices. They can ask questions, make predictions, collect data and draw conclusions, and experience science inquiry first-hand.

These resources can be used and adapted to meet the particular needs of your learning environment and participating kids. Whether you are a program director, classroom teacher, after-school and summer provider, PBS station staff or any other adult working with young kids, these resources are for you!

Resources are grouped by activities, videos and games (online and mobile), and include a list of books related to the topic of Structures. Resources can be used asis, adapted, grouped to make a complete lesson, integrated into preexisting lessons or used as a jumping off point for your own lesson ideas.

For more resources, visit: pbslearningmedia.org/collection/rtl-educator

Videos

The Cat in the Hat Knows a Lot About That! "Design Time" Grade Level: PreK-K

Sally is trying to make a vase for her mother but each one she tries falls over. Cat in the Hat takes Nick and Sally to Blueprintia where designs become real. Through engaging in the Engineering Design Process they discover what they can learn by designing, testing and improving their ideas, which helps solve Sally's challenge.

The Ruff Ruffman Show "Building is a Breeze" Grade Level: K-2

Explore structural science as Ruff Ruffman uses his new service- "Ask Ruff First" or "ARF"-to help kids' mini-golf tower from tipping over in the wind. In the video, Ruff recalls the story of his great-great-great-grand-uncle Ruffois and his assistant Blossom, who discovered that cutting holes in a tower can prevent it from falling. This video has been captioned in both English and Spanish.

The Ruff Ruffman Show Eye of the Hamster **Grade Level: K-2**

Explore structural science as Ruff Ruffman uses his new service—"Ask Ruff First" or "ARF to entertain a bored hamster in this video from The Ruff Ruffman Show. According to Ruff, building an obstacle course is a great way to entertain a hamster. However, remembering how he'd trained for a dogcathalon, Ruff admits he could never figure out how to build the sky-bridge without it collapsing. This video has been captioned in both English and Spanish.

Zoom

Columns: Finding the Strongest Shape Grade Level K-8

The shapes of a structure and its parts are often as important as the materials those parts are made of. In this video segment adapted from ZOOM, members of the cast bend and fold sheets of paper to see which shape is strongest and can best support the weight of a heavy book. This resource is useful for introducing components of Engineering Design (ETS) from the Next Generation Science Standards (NGSS) to grade K-8 students.

Activities

The Ruff Ruffman Show! Teacher's Guide: Structures Grade Level: K-2

Targeted to students in kindergarten to second grade, this science resource collection from The Ruff Ruffman Show features teacher's guides, YouTube-inspired videos, digital games and student activities in English and Spanish starring canine host extraordinaire, Ruff Ruffman. Ruff, along with his trusty assistants Blossom the cat and Chet the mouse, answers questions from kids, takes on challenges, and learns the value of failure-all while modeling science inquiry skills and learning about core science concepts. Bring the fun of Ruff's scientific investigations into your learning environment and use the letters to families to extend the learning at home!

The Ruff Ruffman Show Architecture Scavenger Hunt Grade Level: K-2

Explore structural science and look for shapes around your school or in the buildings in your neighborhood.

The Ruff Ruffman Show

Tower Time Activity Grade Level: K-2 Explore structural science and try to stack a tall and stable tower.



The Ruff Ruffman Show Hamster Run - Ruff Ruffman Grade Level: K-2

Build structures to help the hamsters reach their food! Use the Engineering Design Process to build, test and redesign in this structural science game.

Curious George Build a Bot Curious George Grade Level: PreK-2

Curious George needs help building robots with different properties.



Iggy Peck, Architect by Andrea Beaty Rosie Revere, Engineer by Andrea Beaty The Three Billy Goats Gruff by Stephen Carpenter Twenty-One Elephants and Still Standing by April Jones Prince Most Magnificent Thing by Ashley Spires



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Teacher's Guide Structures

Overview

Exploring structural science with Ruff is a great way to engage students in science learning. In this series of episodes, Ruff has a consulting company, "ARF - Ask Ruff First," that helps people solve building challenges. Ruff learns about properties of materials, force and motion, and stability as he designs, tests, builds (and breaks!) different structures.

This guide will help you bring the fun of Ruff's scientific investigation to your students. There are four parts:

- 1. Background Information
- 2. Science Talk
- 3. Let's Investigate: 2D to 3D Challenge
- 4. Extensions

You can find all the resources referenced below on PBS LearningMedia: www.pbslearningmedia.org/collection/ruff-ruffman-show



Background Information

Bringing Ruff Ruffman into the classroom provides an opportunity for students to investigate and develop a deeper understanding of building materials and forces that affect structures.

As an ARF building consultant, Ruff learned many things about how forces and materials affect a building's stability. Some of the concepts covered in the videos include:

- ★ There are lots of different kinds of structures.
- ★ Different forces, like a weight or the wind, act on structures.
- ★ The shape, weight, size, and symmetry of a structure affect its strength and stability.







Developing Understanding

Children may have had other experiences seeing structures interact with forces and perhaps falling down, toppling over, or not being able to hold a weight. Some questions you might encounter as they work to reconcile their thinking include:

- ★ Is an earthquake a force?
- ★ Can rain weaken a building?
- ★ What is the best way to hold a building together?
- ★ Can you put heavy things on light things?

Acquiring New Science Words

Young learners can benefit from having Word Walls to help them communicate their developing ideas. Including pictures of the word in context, whether it is a classroom investigation or a media resource like a Ruff Ruffman video, can help students remember the experience that corresponds with the word.





Talking about science – by making observations, sharing ideas, and participating in group discussion – is an important science practice. Watch the Ruff Ruffman videos with your students, and use the discussion prompts on the next page to engage in science talk.

As different building problems are presented to ARF, Ruff and the children discover how forces act on structures. Scientists have to solve problems like these on a regular basis. Learning to be resilient can help us be successful in science. A great way to help young students adopt resilient habits of mind is to create "Resiliency Thought Bubbles" filled with phrases they can use when they're faced with a challenge. Ruff is illustrating how this might work in the image to the right. In **That'll Work!** Ruff sings about all he has learned and how he approached each challenge. It's a fun song to play as you create the thought bubbles as a class!



Discussion Prompt 1

Every time a structure is built, there are forces acting on it. Stack a series of objects, like blocks or empty boxes, to make a tower. Challenge the students to identify the forces that might act on the structure. You can reference examples from **Building** is a Breeze and Winging It.

Discussion Prompt 2

In **Eye of the Hamster** and **Ruffman Escapes!** Ruff uses materials in a new way to create a structure for a specific purpose. Ask students if they have ever used a material or object in a new way. What problem were they trying to solve and why did they choose that specific material or object? How did they test if the material or object was the right solution? Did it behave as they predicted?



Let's Build: 2D to 3D Challenge

Ask students how many of them have ever heard of 3D and if they know the difference between 3D and 2D. As a class, watch **Eye of the Hamster** and stop at 1:54 when the drawing comes up and at 2:17 when the children decide to build a test model. Have a brief discussion of how Ruff was pretty certain his drawing for a hamster obstacle course would work, but when they made a 3D model, he was surprised when the spheres rolled away!

Tell students that they will be drawing a dog house and then turning their 2D drawing into 3D creation. If they need a bit of inspiration of how to make something 3D out of paper, they can watch **Ruffman Escapes** to see how rolled paper and tape made a chair to help Ruff escape!

Ask Questions

- ★ Have you ever made a drawing into something three-dimensional?
- ★ How could making a drawing into a three-dimensional structure help us think about building?

Get Set

Materials:

- Paper for drawing
- Scrap paper for building
- Scissors
- Masking tape
- Pencils

Build

Have the students draw their dog house ideas. Remind them to think about what materials they will need to turn the drawing into a 3D model.

- ★ When students are finished drawing, invite them to get the materials they'll need to build their structure.
- ★ As they're building, ask students about what forces might act on their structures and why they think their dog house will be strong.
- ★ When they're done, have students explain what they learned by turning their drawing into a 3D model, and if they would change anything about their design.

Debrief

Gathering students to debrief after an activity is an important part of a science learning experience. Students can use the following sentence starters to help share their learning.

- ★ To communicate their observations: "I saw..."
- ★ To reflect on the process of making something 3D from a 2D drawing: "I thought... but then..."
- ★ To think forward and make improvements: "Next time I might try..."
- ★ To demonstrate science community skills: "I liked…" or "I respected…"
- ★ To make a conclusion: "If Ruff Ruffman wants to build a dog house, he should…"



Extensions

- ★ Students can test their building skills in Hamster Run. Once they have mastered building and seeing how shapes interact, they can then create their own virtual challenge.
- ★ A great next step is to have students do an Architecture Scavenger Hunt to find shapes around the school or their neighborhoods. They can bring their discoveries back to the class and share them in another Science Talk!





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Architecture Scavenger Hunt

Can you find these shapes around your school or in the buildings in your neighborhood? Draw a picture of the shape and where you found it.





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Activity Tower Time

Measure the height of your tower. Then draw your finished tower in the space provided.

How tall is your tower? _____ inches



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Tower Time

Kid Description: Grab a grown-up and some friends for this building game. Can you stack a tall, stable tower?

structural science (shape

Explore:

45-60 minutes

Time:

of structure affects stability), material

This activity is best played on the floor with two to four players. If you have more than four players, break up into teams. If you have kids with motor issues or who otherwise cannot participate, ask them to help take measurements or document.



BS

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Materials:

problem, create, test, and

mprove)

design process (define a

properties, engineering

- Gather up a bunch of household items with different structural elements: wide bases, thin bases, surfaces, heavy things, and light things. Here are some suggestions, but feel free to use your own!
 - Building materials: cardboard tubes, cereal boxes, plastic bottles, paper plates, card stock, paper/ plastic cups, shoe boxes
- Measuring Tape/Ruler
 If you are playing this as a competition, you'll need a set of duplicate materials for each team.



Wonder

- Sit in a circle and pass around the materials. Give everyone one material to explore.
- ★ Ask kids to use their senses to explore each material.
- Ask: What are these materials?
- Ask: Let's investigate how strong these materials are. Try tapping them on the floor. Do they feel strong?
- Ask: Which pieces would make a good base? A base is something wide and strong that goes on the bottom to make the whole tower strong.
- Ask: Based on your explorations, which materials do you predict will work best for a tower? Would you put them on the top or bottom of a tower? Why?
- Put the materials back into a box/bag before explaining the rules.

5

Define a Problem

- Explain the rules of the game (Choose one version):
- **Competitive:** Each team is going to work together to make a tall, stable tower. You'll have the same sets of materials, and will take turns putting down your pieces. After everyone has placed three pieces, we'll measure and see which team has the tallest tower!
- Non-Competitive: You are going to work together to make the tallest, stable tower you can! Everyone is going to take three turns putting one piece of the tower down at a time. We will take turns adding pieces until we have made a tall tower, and then we'll measure!

Create and Test

- Organize the materials in piles for each team.
- ★ Time to start building!
- If you have more than 4 kids, split them into teams. You could make it a competition.
- Encourage the kids to take turns and to place just one piece at a time.
- If the tower falls down, and it's just a small fix, ask the kid to reassemble the fallen piece.
- If the tower falls down completely, jump to Reflect and then ask the kids to redesign and rebuild their tower.
- ★ If kids need more support:
- Hint: Wider objects make a good base for other materials to go on top.
- Hint: Medium-sized objects can make good supports for the middle of a tower.
- Hint: Smaller, narrow objects are usually better for the top of a tower.
- Hint: Try folding paper to make it sturdier.
- ★ After three turns each, the game is done!
- Use your measuring stick or ruler to measure the towers.

If you played in teams, compare towers to see which team built the tallest tower.

Reflect

- ★ Have everyone sit or stand together again.
- Ask kids to document the tower that they made by drawing it on the printout. Encourage them to draw what they used for the top, middle, and base of their tower.
- Ask: On the printout, document what your tower looked like. Draw what you used for its top, middle, and base.
- Ask: Did your tower fall down? Why do you think that happened?
- Ask: How would you improve your tower if you built it again? Are there other materials you'd like to try?
- If you play the game again, use your drawings to help you redesign the towers.



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Time:

45-60 minutes

Explore:

structural science, (shape of structure affects stability), material science, engineering design process (define a problem, imagine and plan, create, test, and improve)

Materials:

Gather up a bunch of household items for kids to build their structures. Each team should have access to the same materials.

Here are some suggestions for materials:

- Large Objects: cardboard tubes, cereal boxes, plastic bottles, paper plates, card stock, paper/ plastic cups
- □ Fasteners: pipe cleaners, rubber bands, paper clips
- Long Objects: straws, popsicle sticks/tongue depressors, toothpicks
 - Wildcard Ideas: tinfoil, plastic wrap, sandwich bags

You'll also need:

- Three sheets of paper per team
- Timer
- 6 inch piece of yarn per team

Tape measure (optional)

Build It Up, Knock It Down

Kid Description: Grab a grown-up and some friends for a building contest! Each team will build a structure without using tape and then try to knock down the other team's structure using only paper. The last one standing wins! This game is for four or more players (teams of two to four) and can be played indoors or outdoors. Each team should find a private space so the other team can't see their structure.

Wonder

- ★ Brainstorm what makes a strong structure.
- Ask: What makes some materials better to build with than others?
- Ask: Does the shape or size of a structure make it stronger? How?
- ★ Lay out all the materials on the floor.
- Ask kids to use their senses to explore each material.
- Ask: How does each material look?
- Ask: How does each material feel? Are they heavy or light?
- Ask: Based on your investigations, which materials do you predict will be the strongest for building?



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Define a Problem

★ Explain the rules:

• Explain: Each team will have 15 minutes to design a structure using only these materials. The tower must be 6 inches tall (hold up the six inch piece of yarn), and you can't use any tape. After you build your structure, each team will have two chances to knock down the other team's structure using only paper.



Imagine and Plan

- ★ Split kids into teams.
- Give each team five minutes to plan what materials they will use and how they want their structure to look. Have kids make a plan by drawing their structure on the printout.
- Explain: Let's make a plan for our structure. On the printout, draw what you want your structure to look like and list all the materials you're going to use.

Create

- If kids are working in larger teams, assign a role to each team member:
- Measurer measures the structure to make sure it is at least 6 inches tall
- Architect compares the structure to their plan
- Clean-up Crew cleans up the materials at the end of the game
- Team Leader makes sure every team member is helping
- ★ Set a timer for 15 minutes. Ready, set, build!
- An adult should work with each group to help resolve any disputes, facilitate the building process, and offer support when asked.
- Remind kids to test the stability of their structures as they build so they can improve upon their structures as needed.
- Ask: Do you think another team would be able to knock your structure down? How could you test your structure to find out?
 - Ask: What materials could you add to make your structure stronger? How else could you improve your structure?
 - Ask: Do you need to change your plan?



- ★ If kids need more support:
- Hint: Use pipe cleaners. Try poking holes in an object using a toothpick and then threading pipe cleaners through. Knot them at the ends to keep them from slipping through the hole. You can also use straws to connect pipe cleaners together.
- Hint: Use rubber bands to group or attach things together.
- Hint: Use a cup as a base, and put other materials in the cup to make it a stronger base.
- After ten minutes, give kids a five-minute warning. Remind them to measure their structure to make sure it's six inches tall.
- ★ Time's up, materials down!



- ★ Have kids reflect as a team.
- Ask: Which materials are the strongest?
 - Ask: What is the shape and size of your structure?
- Ask: How is your finished structure different from the one you planned?
 - Ask: Is there anything you would do differently next time?

Share

- Optional: Take photos of each structure to document each design before trying to knock them down.
- Give kids five minutes to tour each team's structure.
- Encourage kids to ask other teams about their structure.
- Questions kids could ask:
- Why did your team choose those materials?
- How is your plan different from your structure?
- How would your team improve their structure if they were to build it again?



Test

- 🖈 Time to knock it down!
- Brainstorm devices kids could make to knock down the other team's structure.
- Explain: You're going to work with your team to make a device using only three pieces of paper that will knock down the other team's structure from five feet away. Each person only gets two tries to knock down the other team's structure.
- Ask: What could you make with paper that would knock down the other team's structure?
- If kids need some help brainstorming, offer a few ideas. (i.e. crumpled balls, paper airplanes, long skinny tubes)
- Use a tape measure (or the same person's footsteps) to set up a marker five feet away from each structure.
- Give each team three pieces of paper. An adult should help facilitate the paper construction and turn-taking.

- Have each kid stand behind the marker and each take turns throwing the device. If a kid throws and misses, the adult could move him closer to the structure. Each kid gets two tries (one try counts if it touches the structure).
- If both structures fall, give teams five minutes (or more, if needed) to reconstruct and improve their designs. Then, get ready to try to knock them down again!
- The team whose structure remains upright wins! If both structures still remain after each kid has had two tries, both teams win.







PBS KIDS

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Materials:	
5	
3.	
4.	
9.	
7	
Prediction:	









It's all in the column!

After a birdbath mishap, Ruff wonders if a different column would make it stronger. Which shape would support the most weight?

Help Ruff build a better birdbath. Using paper and books, investigate with three different birdbath models to find the strongest design.

Materials:

- Column templates
- Tape
- Books

Instructions:

- 1) Print the column templates (on the following pages) and construct three different shaped columns square, triangle, and circle.
- 2) On a hard surface, stand the three columns on end. Can you predict which shape is the strongest?
- 3) Place a book on top of the first column to create a birdbath platform. Now place that same book on the second and third columns. Did any of the columns support the book?
- 4) Now try placing two or three books on the remaining columns. To keep the weight equal, stack the same books on each column. Which was the strongest? Was your prediction correct?

REMEMBER: Columns are most stable with a balanced load. Place the books evenly on top of each column.

More Ways to Play:

- Can you build a structure that holds three or more books?
- Try using more than one column.
- Try using different types of paper.







For more fun, visit: pbskids.org/ruff

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Square Column

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Triangle Column

(fold)



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Circle Column





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