National Inventors Hall of Fame®
EDUCATION PROGRAMS

READY, SET, STEM HANDBOOK

Get set to invent with these at-home family activities

LET'S GET CREATIVE!

We put this handbook together to inspire young innovators everywhere. Here, you'll find hands-on, open-ended activities designed to spark creativity as you and your kids work together to design, prototype, explore STEM concepts and overcome real-world challenges.

Before we get started, we have just one question: Do you have a space devoted to creativity? It doesn't have to be big or fancy – just a simple space where your kid can create and invent. Here are a few basic tips for making your own innovation station:

1. Choose the right location

Would your child prefer a quiet corner of the family room, or maybe a desk in their bedroom? Think about how a space might inspire creativity, as well as how easy it will be for you to supervise when necessary.

2. Gather supplies

Provide an organized array of simple supplies including pencils, paper, scissors, glue and recyclable materials from around your home. Remember, amazing prototypes can be built with the most basic materials.

3. Make your mark

Consider giving your child the chance to make this space their own. Whether that means painting their desk or simply hanging a few posters, you can support their sense of ownership and pride in their innovation station.

Ready to use your imagination and put creative problem-solving skills into action? Let's go!

Happy hands-on creating,
Your National Inventors Hall of Fame® team

TAKE APART

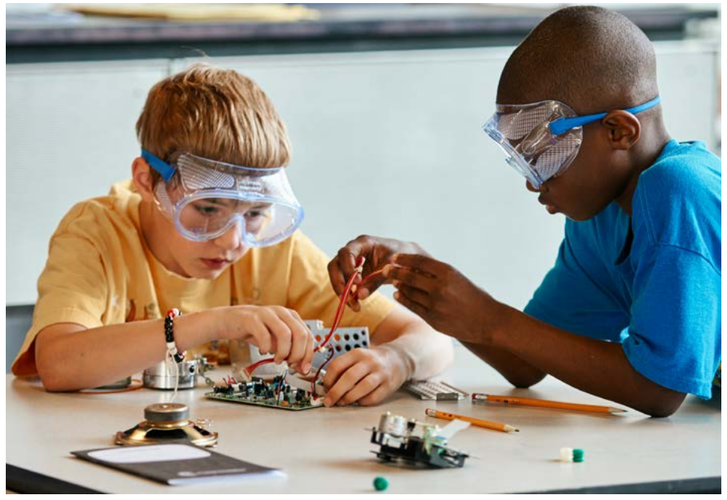
In this hands-on STEM activity, children explore the inner workings of everyday items around the home to better understand how they function!

WHAT ARE WE LEARNING?

Discovering "what's inside" is a foundational skill that fuels curiosity and innovative thinking. NIHF Inductee Jim West, co-inventor of the electret microphone, has said that as a young child he took apart his grandfather's pocket watch to see how it worked. In fact, many of the world's greatest innovators have cited taking apart discarded gadgets at home as a key experience.

MATERIALS NEEDED

- Safety goggles
- Utility pliers
- Needle-nose pliers
- Wire cutters
- Claw hammer
- Hex key
- Screwdrivers
- Utility pry bar
- Take-apart item of choice



INSTRUCTIONS

Selecting an Item

1. Ideal take-apart items contain many parts, such as motors, magnets, gears, screws and circuit boards. One of the best examples is a VCR.
2. Avoid items containing a lot of molded plastic as they are difficult to break open.
3. For safety reasons, do not take apart cameras, cellphones, irons, computers, microwaves, monitors, printers, rotary phones, televisions, toasters, vacuums, video game consoles or any items that contain glass.

Preparing the Item

1. Remove any batteries. Unplug the item for four days to discharge capacitors before taking it apart.
2. Use wire cutters to remove all electrical cords.
3. Children may have difficulty loosening screws. Allow them time to be successful. Consider loosening screws ahead of time so children can accomplish the task on their own.

Taking the Item Apart

1. Tell participants they will be using real tools to take apart a machine!
    - Explain that machines are held together by many screws and that they may have to remove them before their machines will come apart.
    - Explain that pliers are used to grab and twist bolts.
    - Show how wire cutters are used to cut wires.
    - Display the types of screwdrivers and demonstrate how they are used to remove specific screws – right to tighten and left to loosen.
2. Explore the anatomy of a machine.
    - Explain that the parts they see are common in many mechanical or moving devices. Work together to identify as many as you can in your item!
3. Begin taking the item apart.
    - Allow children to take the lead while you assist with sketching and recording observations, supervising them as they remove parts.
4. Congratulate and discuss.
    - Ask the children what the inside of their machine looks like.
    - Reflect on the process together, discussing what was found and what the next steps should be.

DIGGING INTO STEM

Create and then excavate your very own ice ball!

MATERIALS NEEDED

- Balloon
- Digging tools (e.g., craft sticks, forks, spoons)
- Flashlight
- Hand towel
- Recyclables (optional)
- Small objects (e.g., beads, mini figures)
- Safety glasses
- Salt
- Tray
- Water

WHAT ARE WE LEARNING?

Polar bears have many features that make them very well adapted to live and hunt on smooth, slippery ice. The bottoms of their paws have black footpads that are covered with many tiny bumps called papillae. These bumps provide traction, helping the polar bear to grip the ice and move quickly without slipping. Humans are not so well equipped on the ice without special gear, but many enjoy gliding across the smooth ice at a rink on skates thanks to NIHF Inductee Frank Zamboni, who invented the ice-resurfacing machine that bears his name to this day.

Working in California, Zamboni and his brothers were partners in an enterprise that made and sold block ice. As the block ice industry declined due to mobile refrigeration, the Zamboni brothers instead used their ice-making knowledge to create an indoor ice rink called Iceland in 1940. The ice rink proved so successful that keeping the ice smooth was a labor-intensive job, requiring a crew of five people to work an hour and a half to complete the job. By 1949, Zamboni created a prototype of his ice-resurfacing machine that could complete the work in 15 minutes.

INSTRUCTIONS

When you think about polar bears, you probably also think about ice. The ice in glaciers comes from snow that is very old. By studying the water, air, dust and other materials trapped in the many layers of snow and ice, scientists can tell what the Earth's atmosphere was like a long time ago. The deeper they dig into the ice, the older their samples become.

1. Prepare an ice ball ahead of time by filling a balloon partway with water, inserting small objects (e.g., beads), and then freezing it. Keep the ice ball size manageable by not completely filling the balloon; it should be able to fit into an 8-ounce cup prior to freezing.
2. Once it's frozen, take it out of the freezer and remove the balloon covering to reveal the ice ball. Set the ball on a tray. (Have a towel nearby to dry and warm your hands!)
3. Turn on the flashlight and examine the ice. Look for the embedded objects. What do you notice about where they are located or how the ice looks?
4. Put on safety glasses and discuss tool safety.
5. Grab your digging tool or get creative and invent your own glacier digger using items like craft sticks, forks, spoons and recyclables.
6. To extract the objects, you must dig into the ice the same careful way that scientists do (e.g., using drilling, boring or scraping actions, and not by hammering or stabbing).
7. Consider adding a spoonful of salt on top of the ice to speed up the process. Salt chemically interacts with the ice and causes it to melt at a lower temperature.

SLOW THE FLOW

When snow melts, river and lake water levels often rise. With this activity, children will create a system to control the flow of water and prevent spring flooding.

MATERIALS NEEDED

- Blocks or building bricks
- Cardboard box, cut into flat panels
- Clay or playdough
- Craft sticks, straws or toothpicks
- Crayons or markers
- Recyclables (optional)
- Wax paper or aluminum foil

INSTRUCTIONS

1. Draw a large river on flat cardboard with markers or crayons.
2. Build a city on the river's edge using blocks or building bricks.
3. Encourage participants to transform their materials into a structure that will keep the river from flooding in order to protect the city.
4. For inspiration, explore the designs of beaver dams, constructed by nature's architects.
5. Remember to make the system waterproof and ensure that it will not cause any harm to the environment or wildlife.
6. Give a tour of your model to a family member or friend!

WHAT ARE WE LEARNING?

Many animals thrive as snow melts and rivers rise in spring, including beavers. When beavers build dams and slow the flow of water, it creates the perfect environment for salmon spawning later in the summer.

However, cities that are built near rivers sometime struggle with seasonal floods when water levels rise. Civil engineers often rely on ideas from great inventors to solve these flooding challenges.

In 1887, NIHF Inductee Harriet Strong created and patented an innovative water storage and flood control system to help slow the flow of water. Her system consisted of a series of dams placed so that the water in a lower basin would act as a brace for the dams above. Major federally supported flood control systems based on Strong's pioneering technology include the Hoover Dam and the All-American Canal.

MATERIALS NEEDED

- Copy paper
- Hole punch
- Magazines or decorative paper
- Markers
- Pencil
- Ribbon, string or twine
- Ruler
- Scissors
- Two pieces of cardstock or thick cardboard

INSTRUCTIONS

1. Design your own superhero storyline for a graphic novel, utilizing innovation as a theme.
2. Stack several sheets of copy paper together. Use a ruler and pencil to make boxes for your sketches. Write your story using both sides of the paper.
3. Turn one of your pieces of cardstock or cardboard into a cover, and design it with markers and other craft supplies.
4. With a pencil, place at least four dots evenly spaced alongside the left edge (i.e., binding) of two pieces of cardstock or cardboard to serve as the cover. The dots should be about a quarter inch from the edge.
5. Place the paper between the covers, punch the holes, and then stitch the pages together with string or thread.
6. Be sure to add your name, the year and a copyright mark (©) before sharing your original work with others.

WHAT ARE WE LEARNING?

Long before there was electronic ink (think of your favorite e-reader), early pioneers of sharing content worked on refining the printing process. NIHF Inductee Richard Hoe invented the rotary press, allowing newspapers to be printed at lightning speed when compared to the original process. A later improvement to his rotary press enabled newspapers to be printed on both sides of the paper in one move. In modern times, it is much easier for people to distribute creative works. With the rapid pace of exchanging information through the internet, we face new challenges. Some of these challenges include creators not receiving credit for their work or having it shared without their permission.

The symbol © indicates that a copyright has been claimed, which means that no one other than the creator or owner has the right to copy, give out, perform or display the work without the owner's permission. Copyrights are for written works (like books and articles), paintings, photographs and recorded music, but not for nonphysical items (like ideas or facts). Original work is automatically protected by a copyright when it is created but it can be registered with the U.S. Copyright Office through the Library of Congress to provide increased protection.

COME GLIDE WITH ME

Experiment with paper airplane design, investigate how wing shape affects flight and explore flight principles through this fun activity.

MATERIALS NEEDED

- Craft supplies (e.g., decorative tape, stickers, etc.)
- Crayons or markers
- Paper
- Paper clips
- Scissors
- Tape

WHAT ARE WE LEARNING?

Most paper airplanes are considered gliders rather than true airplanes. When you are testing your paper airplanes, you throw them forward to provide thrust. After the initial thrust, the paper airplane flies by gliding. Drag, the opposing force to thrust, is always pushing the gliders slightly back, slowing them down. When you bend the paper airplane's wingtips up or down, it affects drag. This is similar to how airplane wings have movable flaps that either give more lift during takeoff or increase drag during landing. When you add paper clips onto parts of your plane, you are adding weight, which changes the center of gravity and center of lift.

Aviation pioneers Orville and Wilbur Wright were inducted into the NIHF for their invention of the airplane. In 1903 they made history's first powered, sustained and controlled airplane flight from level ground without assistance at takeoff.

INSTRUCTIONS

1. Select a paper airplane design to fold, or create your own.
2. Use these paper airplane folding tips to ensure a smooth flight:
    - Paper airplanes should be symmetrical (the same on both sides). Take extra time to line up corners and meet center lines precisely when folding.
    - Make sure the folds are extra crisp.
3. Decorate your airplane using markers, decorative tape or stickers.
4. Test your paper airplane. Try out a few modifications, observe how your airplane glides, and record any notes on how the different wing designs affect your airplane's flight.
    - Bend the wingtips up.
    - Bend the wingtips down.
    - Bend one wingtip up and one down.
    - Add paper clips to the nose.
    - Add paper clips to the wings.
    - Add paper clips to the tail.
5. Select another paper airplane design to fold and observe how it differs from your first paper airplane.

DESIGN A SMART ROOM-CLEANING ROBOT

What if you could clean your entire room without moving from one spot? Let nature be an inspiration as you dream up, sketch and prototype the ultimate room-cleaning robot.

MATERIALS NEEDED

- Aluminum foil
- Craft materials (e.g., clay, craft sticks, pipe cleaners, string)
- Disposable materials (e.g., paper cups, plates, toothpicks, utensils)
- Drawing materials (e.g., pencils, markers)
- Masking tape
- Office supplies (e.g., paper clips, rubber bands)
- Recyclables

INSTRUCTIONS

1. Research ways in which plants and animals have inspired inventions. This is referred to as biomimicry.
2. Make a list of the actions you want your robot to accomplish, such as: pick up, grab, sort and move objects.
3. Now research plants and animals that use the same actions you want your robot to perform. You can start by reviewing the following facts:
    - A platypus can use its bill to sort food.
    - Octopus tentacles can reach and grab.
    - Bacteria colonies build themselves into patterns.
    - A Venus flytrap's leaves close to capture prey.
    - Spiders use sticky webs to catch and hold prey. They also make a spiral of nonsticky threads in the center of their webs, which allows them to easily move around during web construction.
4. Brainstorm ways to build a robot with features that mimic plants and animals.
    - How will your robot recognize what needs cleaning?
    - How will it reach the items?
    - How will it organize objects? By size? Type? Shape?
5. Gather drawing materials and sketch designs for your robot. Think about how different toys and gadgets around the house function. How can you incorporate these functions and designs into your robot?
6. Build a prototype of the robot you designed. Use recyclables and other available craft supplies.
7. Test your design! If it does not work as you intended, can you identify what it is that needs to be changed? How will you adjust? What is working in your design? How can you use that information to continue developing your prototype?
8. Take your room-cleaning robot to a smarter level! How might you incorporate smart features, such as voice activation or the ability to control it from a smartphone? Could it have sensors that alert you when a task needs to be accomplished? Maybe it could sense the height of a pile of clothes on a chair? Be sure to record your ideas. Think big and have fun!

WHAT ARE WE LEARNING?

Inspiration is everywhere, and we can use everyday objects in new ways to solve problems. In this activity, children define a simple design problem reflecting a need or a want that includes specified criteria for success. They are also exploring design thinking and observing people, plants and animals and how they use objects, products and processes. Many businesses are looking to nature and the features and abilities of animals and plants to innovate, which is called biomimetics.

A classic example of biomimetics can be found in the invention of VELCRO® fasteners. In 1948, NIHF Inductee George de Mestral, who was an amateur mountaineer, made a discovery that changed the way he looked at the burrs of the burdock plant. While pulling burrs from his jacket, he began to think about how they could stick to everything from his socks and jacket to his dog's ears and tail. Upon further investigation with the help of his microscope, de Mestral discovered that there were tiny hooks that entangled themselves in the loops of fabric and fur. This allowed the seedpod to catch a free ride on the fur of passing animals. This discovery inspired de Mestral to design a unique, two-sided fastener that launched a multimillion-dollar business.

OCEAN CLEAN-UP DEVICE

Reduce pollution by inventing ways to remove waste from the ocean, while making sure that the marine life remains unharmed.

MATERIALS NEEDED

- Pony beads, plastic cups and/or other small items to represent pollutants
- Rubber fish or objects that represent marine life
- Small container, bucket or inflatable pool
- Upcycling and crafting materials that can be used to create inventions
- Water

INSTRUCTIONS

1. Research the garbage patches that form in the world's oceans. Brainstorm solutions to clean up these problematic areas.
2. Fill a container, bucket or pool to represent the ocean.
3. Place various objects in the water to represent marine life (e.g., rubber fish) and pollutants (e.g., pony beads, plastic cups).
4. Invent a device that can remove plastics and other objects from the water, but avoids bycatch (untargeted aquatic or marine life)!
5. Test, modify and retest the device. Then, celebrate being a green (and blue) change agent!

WHAT ARE WE LEARNING?

This hands-on STEM (science, technology, engineering, and mathematics) activity gives children the opportunity to build the creative-thinking skills that are needed to solve complex challenges. NIHF Inductee Jacqueline Quinn embraced the power of teamwork when developing the environmentally safe clean-up technology emulsified zero-valent iron (EZVI) with a team of researchers at the University of Central Florida. Today, EZVI is licensed for commercial use and is used to decontaminate groundwater that contains dense nonaqueous phase liquids.

COFFEE COMPOST

Explore the science behind composting!

MATERIALS NEEDED

- Coffee filters
- Used coffee grounds
- Leaves
- Grass clippings
- Craft supplies (stickers, fabric, decorative tape, etc.)
- Drawing utensils (crayons, markers, paints, pencils)
- Used single-use coffee pods
- Paper
- Planting soil
- Scissors
- Small plants or seeds
- Tape
- Water
- Outdoor area for compost

INSTRUCTIONS

Part 1: Create Compost

1. Brew a cup of coffee and explain to your kids that the used grounds can be reused to aid plant growth!
2. Before using these old grounds in a new way, set aside an area in your yard where you plan to make your compost pile.
3. For one month, mix and spread your used grounds and coffee filters along with grass clippings and leaves across your designated compost area. The mixture should have an equal amount of each ingredient.
4. This composted material can now be used as fertilizer for flowers and plants in your home or garden!

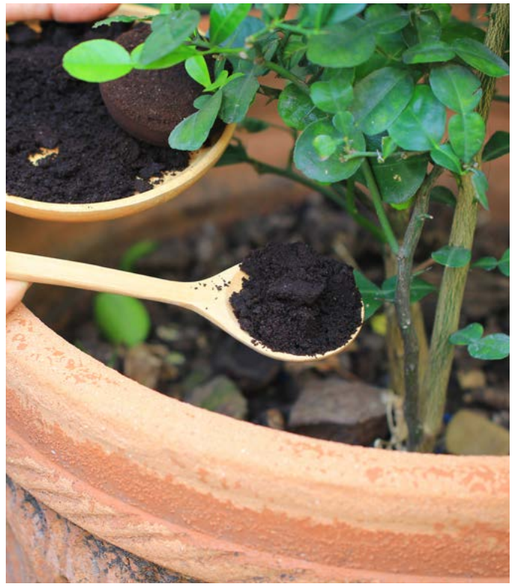
Part 2: Upcycle Coffee Pods

5. While the convenience of single-use coffee pods has made the process of brewing coffee easier than ever, unfortunately, they create a large amount of plastic waste. To mitigate these effects, repurpose these pods by turning them into miniature planters.
6. Have your children sketch their ideas. Will their planter use one pod or many? How will they attach the pods to each other?
7. Using tape, scissors, paper, crayons and other craft supplies, have participants design and decorate their planter.
8. Next, fill each planter with soil by placing one small plant or seed in the center of each.
9. Water each cup regularly to keep them growing.
10. If you created compost, add a pinch to each cup to act as a fertilizer.
11. Show off your upcycling prowess by taking a photo of your coffee creations and tagging NIHF on social media! We always love to see your innovative creations!

WHAT ARE WE LEARNING?

Humans have been drinking coffee since the 15th century. It has been brewed in many different ways over time, but the process always involves pouring boiling water over ground coffee beans. In 1948, an American inventor and NIHF Inductee, Percy Spencer, invented a special coffee brewing device that harnesses the power of microwave energy.

Because coffee is such a popular drink, used grounds are common in many homes. Often, the grounds are thrown out. However, families can repurpose them to use as composting material. Because coffee grounds are an effective nitrogen source, they are especially effective when mixed with other compostable materials. Creating compost is a great way to reduce landfill waste and create a useful material many people dispose of daily.



HYDRO-DIPPED SCIENCE GIFT

Let your creativity flow as you explore principles of fluid dynamics to create a one-of-a-kind gift! Dip a canvas panel or ceramic into a swirl of spray paint to reveal a beautiful masterpiece.

MATERIALS NEEDED

- Large bin or bucket
- Canvas panels or ceramic tiles (8 by 10 inches or smaller)
- Disposable gloves
- Enamel spray paint, various colors
- Paper towels
- Particulate mask
- Plastic drop cloth or old plastic tablecloth
- Safety goggles
- Water

WHAT ARE WE LEARNING?

The spray paint floats because oil and water separate when combined. The Archimedes principle explains this phenomenon, and states that "the buoyant force on an object submerged in a fluid is equal to the weight of the fluid that is displaced by that object." Because oil is less dense than water, this causes the oil-based spray paint to skim on top of the water.

Many inventors draw inspiration from the arts. For example, NIHF Inductee Samuel Morse, who invented Morse code and the telegraph, was a portrait painter. NIHF Inductee Radia Perlman has a passion for playing the piano. NIHF Inductee Hedy Lamarr was a famous actress, and her co-invention of a frequency-hopping signal led to modern wireless communication.

INSTRUCTIONS

1. Select a canvas panel or ceramic tile with a matte finish.
2. Find a well-ventilated area. Select a large bin or bucket large enough to submerge the canvas or tile. Fill the bin or bucket three-quarters full of water and place a tarp on your working surface or floor.
3. Wear clothing you don't mind getting messy. Wear a pair of disposable gloves to protect your hands, safety goggles to protect your eyes and an inexpensive particulate mask to protect your lungs.
4. Choose your favorite colors of spray paint and spray the surface of the water in your bin or bucket. Choose another color of spray paint and spray some more! Continue until you are satisfied with the look of the paint on the surface of the water.
5. Slowly lower the canvas or tile at an angle so the paint adheres to the surface of the canvas or tile.
6. Once the canvas or tile has been entirely dipped through the paint, pull it out of the water. If you don't want any more paint on your tile or canvas, pull it through the surface of the water where there is not much paint. Then set it aside to dry.
7. Experiment with different paint colors to see what happens! Try moving or swirling the colors before dipping. Let your gift dry and wrap it for delivery!

DESIGN A FLAG

Design your very own flag while learning about logos and trademarks!

MATERIALS NEEDED

- Craft items (e.g., foam sheets, patterned tape, stickers)
- Dowel or stick
- Glue
- Markers (or other drawing utensils)
- Paper or fabric
- Tape

WHAT ARE WE LEARNING?

Just as flags distinguish countries and states from one another, logos are often used on products and packaging to help differentiate one business or product from another. For a logo to be successful, it should communicate information about the company or product through its font, color palette and imagery. Logos can be protected with either a trademark (TM) or a registered trademark® symbol if the owner is able to demonstrate that the logo can identify or distinguish the source of goods and services. For more information on trademarks and other forms of intellectual property, visit USPTO.gov.

INSTRUCTIONS

1. Consider how flags often have colors and symbols that tell a story. The United States flag, for example, has 13 horizontal stripes that alternate red and white. The stripes represent the original 13 colonies and the stars represent the 50 states.
2. Think about how products and companies also have a special design that represents them and tells their story. These special designs are called logos.
3. Grab paper and markers (or other drawing utensils) and design a logo that represents your family. Logos can be made up of letters, words, symbols, colors and other details. While you are designing your family's logo, consider some of the following questions:
    - What is your favorite way to spend time together?
    - What are some unique or special features about your home?
    - Do you have a favorite shared food, hobby or activity?
    - What colors or patterns best represent your family?
    - What are the special talents within your family?
    - When people think about your family, what comes to mind?
    - How might you represent important family values, like kindness or patience?
4. If it is challenging to get started, consider using a shape, such as a circle, square or oval, as your base.
5. Once you have designed your logo, create a flag that features the logo as the main symbol. You can draw it on copy paper and tape it to a dowel (or stick). Alternatively, put your crafting skills to the test by drawing your logo on a piece of fabric and attaching it to a piece of rope or string.
6. Place your family's flag in a prominent place and let it remind you of the special connections that you share.

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