

INVENT IT. BUILD IT

INVENTION—MAKING THE WORLD A BETTER PLACE



FOR 9- TO 12-YEAR-OLDS IN AFTERSCHOOL PROGRAMS



in collaboration with



Inspiring a New Generation of Inventors

as built on TV.



the **Lemelson** foundation
improving lives through invention

Dear Afterschool Educator:

The Lemelson Foundation is delighted to bring you the *Invent It, Build It* guide. It builds on the rich resources of *Design Squad* and Lemelson-MIT InvenTeams to engage young people ages 9 to 12 in the creativity and possibility of invention. The guide's six invention challenges emphasize teamwork, creative problem solving, and how invention improves people's lives.

The activities reach young people at a time in their lives when they are still intrigued by the world around them. Our goal is to spark their investigative spirit, promote creativity, help them think through problems, and express their ideas through building things. This process stimulates young people's interest in math, science, and engineering. It also connects the process of invention to their everyday lives and to a broad range of careers and social issues.

Established by Jerome Lemelson, one of America's most prolific inventors, the Lemelson Foundation sparks, sustains, and celebrates innovation and the inventive spirit. Its programs in the U.S. and in developing countries support invention-led economic, social, and environmentally sustainable development. The Foundation works with partners to recognize and celebrate accomplished inventors, provide financial and mentoring support to grassroots inventors, offer hands-on opportunities that enable young people to develop their budding scientific curiosity, and disseminate technologies that improve people's lives.

In this spirit, we encourage you to use the *Invent It, Build It* guide to bring invention and engineering to life for young people and inspire them to investigate and solve challenging problems. Together, let's help the next generation of inventors make the world a better place!

Sincerely,



Dorothy Lemelson
Chair



Julia Novy-Hildesley
Executive Director

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Competition plus engineering equals fun! *Design Squad* gets kids thinking like engineers and shows them that engineering is fun, creative, and something they can do. Watch it on PBS and visit the Web site to get episodes, games, 35 hands-on challenges, and much more.



Invention, here we come! Through design challenges, educational resources, and grant programs, InvenTeams engages kids in invention, empowers them to problem solve, and encourages an inventive culture in schools and communities.

HOW TO USE THIS GUIDE

The guide's challenges take about an hour, use readily available materials, give kids many ways to succeed, and are aligned with national science and technology standards. You can use them in a:

- **one-time session**—like a workshop or event. Every challenge can be done as a stand-alone experience.
- **series of sessions**—like an invention club or an afterschool science or engineering program. Want to start an invention club? See page 7.

TO GET STARTED

- **Read the leader notes.** Found at the beginning of each challenge, they'll help you understand how to prepare for and run a session.
- **Try the activity yourself.** A practice run will help you figure out the best way to introduce the activity and anticipate potential problems your kids may run into.
- **Print the challenge sheet.** This handout for kids—a cartoon strip featuring *Design Squad* host Nate Ball—presents the problem to solve. It also provides the context for the challenge, questions to help kids brainstorm design ideas, and tips for building and troubleshooting.
- **Decorate the room.** Set the stage for creative thinking, and get kids excited about invention. Post the tear-out invention posters found in the appendix. Also, *Invention Resources* (page 42) lists Web sites that feature wacky inventions, inspiring quotes about invention, and interesting profiles of inventors. Visit the Web sites, find items that you like, print them out, and post them around the room.



Invention appeals to anyone who loves using his or her ingenuity to problem solve and make a difference in the world.



Leader notes page



Kids' activity handout

TO LEAD A CHALLENGE

Never led an invention activity? Don't worry! The leader notes give you all you need to facilitate a session. The leader notes are divided into the following sections:

- **The invention challenge**—Presents the goal for the session and the steps involved in running the challenge. Each challenge is designed to help kids (who work in groups of two or three) understand that inventors look for ways to improve people's lives.
- **Prepare ahead of time**—Lists things to do to get ready for the activity.
- **Warm-up activity**—Gives kids an opportunity to practice a particular inventive thinking skill (e.g., improvisation, flexibility, and visualization) that they'll use more extensively as they tackle the session's challenge.
- **Introduce the challenge**—Provides an attention-grabbing story for you to read aloud. The story gives kids a real-world context for the challenge's problem as well as a sense of relevance, purpose, and meaning for their own inventing.
- **Brainstorm design ideas**—Helps kids think about different ways to meet a challenge.
- **Build, test, and redesign**—Lists issues that might surface during a challenge and suggests strategies to use with kids who face these issues.
- **Discuss what happened**—Provides questions (and answers) that review the activity's key science and engineering concepts, helping kids reflect on the design process and how the challenge relates to invention.
- **Tinker some more**—Presents extension activities that reinforce and expand the experiences kids have had in a challenge.



If a design doesn't work as planned, encourage kids to try again. Setbacks often lead to design improvements and success.

TIPS FOR FACILITATING OPEN-ENDED CHALLENGES

- There are multiple ways to successfully tackle a challenge. One solution can be just as good as another. Help kids see that the challenges are not competitions. Instead, they're opportunities to unleash an individual's ingenuity and creativity.
- When kids feel stuck, have them describe why they think they got the results they did. Ask questions rather than telling them what to do. For example, ask: "Why do you think this is happening?" or "What would happen if...?" or "What is another thing you could try?"
- When something's not going as desired, encourage kids to try again. Have them compare their design to other kids' designs. Remind them that problems are opportunities for learning and for using creative thinking.
- Have kids come up with several ways to solve a problem before they move ahead with an idea.

TALKING WITH KIDS ABOUT

INVENTIONS BY KIDS

Even people with very little training can be inventors

- **Earmuffs** (Chester Greenwood, age 15)
- **Makin' Bacon—a quick, healthy way to cook bacon** (Abigail Fleck, age 8)
- **Popsicles** (Frank Epperson, age 11)
- **Fantasy baseball game with trading cards** (Dustin Satloff, age 10)
- **Sifting shovel for separating soil from leaves** (Kaileigh Kirton, age 11)
- **Helmet for sailors** (Palmer Rampell, age 15)
- **The cathode ray (TV) tube** (Philo Farnsworth, age 14)
- **Glow-in-the-dark writing pad** (Rebecca Schroeder, age 10)
- **Braille alphabet for the blind** (Louis Braille, age 12)
- **Crayon holder for broken crayons** (Cassidy Goldstein, age 11)

WHO, ME? AN INVENTOR?

Yes! People from every corner of the world, of different ages, with different levels of education invent by identifying problems, pursuing ideas, and developing new solutions. The key to inventing is identifying a need and devising an original solution.

Maybe a better question is, “Is there anyone who isn’t an inventor?” Let kids know that everyone has the capacity for invention. We all solve problems through inventive thinking, whether it’s figuring out a way to prop open a window, stay dry in a rainstorm, or build a playhouse from scrap materials. Creative problem solving, improvisation, flexibility, and tinkering drive the inventive spirit.

WHAT’S AN INVENTION?

Let kids know that an invention is a useful creation that didn’t exist before. Round out their understanding of invention by sharing the characteristics below.

- An invention usually fills a need or solves a problem.
- Inventions often make the world a better place.
- Inventions can be things (e.g., a cell phone or backpack) as well as ideas (e.g., a new method for tying a knot, or a story).
- An invention often makes something better (e.g., faster, stronger, cheaper, easier, safer or more efficient, attractive, useful, accurate, fun, or productive). But as long as it’s a new way to do something, it’s still invention even if it isn’t necessarily better than what existed before.

WHY INVENT?

Inventing is a process. It starts with a need and ends up with something new—the actual invention.

- **To solve problems:** Inventors are skilled at spotting ways to improve a situation or process. The activities in this guide help kids develop solutions to problems by applying the design process.
- **To improve our world:** Imagine how different our lives would be without inventions, such as computers, refrigerators, electricity, plastic, and medicine. The activities in this guide show how inventions improve things at home, at school, in the community, and in the world.
- **To enjoy the creative process:** Invention involves both thinking and doing. The activities in this guide help kids become involved in the process of thinking about a problem and then doing something about it. Because they create their own solutions, kids get excited about the process of inventing.

INVENTING

INVENTORS AND ENGINEERS ARE SIMILAR IN MANY WAYS

Engineering is a process for developing solutions to problems. Inventing is a process for creating things that didn't exist before. Inventors sometimes use engineering to create new solutions, but, as discussed on page 4, many do not. Both inventors and engineers look for ways to improve things in areas like health, food, safety, transportation, aerospace, electronics, communication, and the environment. And when the improvement is something new, it's an invention.

DISPEL THE STEREOTYPE THAT SURROUNDS ENGINEERING AND INVENTING

There's a stereotype that engineering is boring and hard. To fight this stereotype, tell kids about some of the exciting challenges inventors and engineers take on to help improve people's lives, and point out how central invention and engineering are in our daily lives.

- Create more fuel-efficient cars
- Design a lighter bike frame
- Invent a more powerful superglue
- Create satellites that detect droughts around the world
- Develop state-of-the-art cell phones
- Invent artificial retinas for people who are blind
- Develop a feather-light laptop
- Design clothing that repels mosquitoes
- Create a wheelchair that can go up stairs

THE PROCESS OF INVENTION INVOLVES:

- identifying a problem and/or realizing that something can be improved.
- talking to people who might use the invention.
- brainstorming creative solutions to a problem, which often involves making imaginative connections between seemingly unrelated things.
- devising and testing solutions (i.e., experimenting).
- applying science and engineering concepts.
- using tools, materials, and techniques to make workable solutions.
- trying again when things don't work out. On *Design Squad*, we say, "Fail fast—succeed sooner!"
- seeing a project through by being motivated, persistent, and dedicated.

FIND OUT MORE

Get activities, profiles of cool inventors and engineers, and more. See page 42 and visit:

Design Squad

pbs.org/designsquad

Discover Engineering

discoverengineering.org/home.asp

Engineer Your Life

engineeryourlife.org

Howtoons

howtoons.com

InvenTeams

web.mit.edu/inventeams

The Lemelson Center for the Study of Invention and Innovation

invention.smithsonian.org/home

INTRODUCING THE DESIGN PROCESS*



The design process is built into each challenge. As kids work through a challenge, they'll see that the steps of the design process encourage them to think creatively about a problem to produce a successful result.

Inventors' and engineers' initial ideas rarely solve a problem. Instead, they try different ideas, learn from mistakes, and try again. The series of steps they use to arrive at a solution is called the **design process**. As kids work through a challenge, use the questions below to talk about what they're doing and to tie it to specific steps of the design process.

BRAINSTORM

- What are some different ways to tackle today's challenge?
- How creative can we be? Off-the-wall suggestions often spark GREAT ideas!

DESIGN

- Which brainstormed ideas are really possible, given our time, tools, and materials?
- Can we phrase it as an invention statement, such as "I will invent an x that does y"?

BUILD

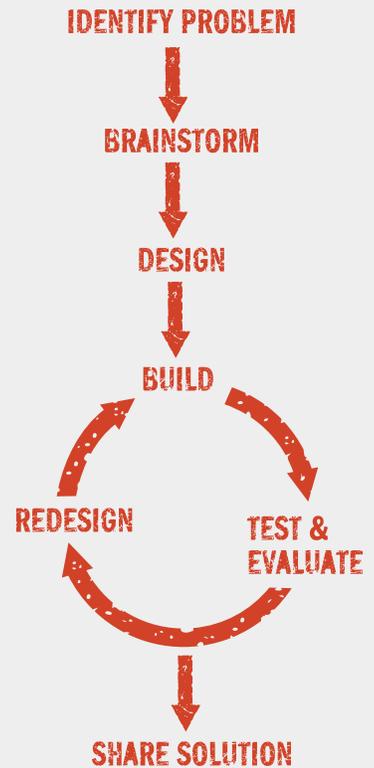
- What are some problems we'll need to solve as we build our projects?
- What materials will you need to build your invention?

TEST, EVALUATE, AND REDESIGN

- Why is it a good idea to keep testing a design?
- What specific goal are you trying to achieve, and how will you know if you've been successful?

SHARE SOLUTION

- What were the different steps you had to do to get your project to work the way you wanted?
- What do you think is the best feature of your invention? Why?
- What are some things our inventions have in common?
- If you had more time, how could you improve your invention?
- Look at the group to your left. What's something you like about their invention and something that could be improved? (This helps to develop teamwork by teaching kids how to give constructive criticism.)



The design process is a great way to tackle almost any task. In fact, you use it each time you create something that didn't exist before (e.g., planning an outing, cooking a meal, or choosing an outfit).

EXPAND YOUR SKILLS

Learn ways to integrate the design process into the projects you do with kids by doing the free NASA/Design Squad online training. Find it at pbs.org/designsquad.

* This design process graphic is available as a tear-out poster on page 39.

SETTING UP AN INVENTION CLUB

The club format appeals to kids. They like being part of a group, having fun together, and having an experience that builds over time. In a club, kids will practice and model for each other important skills, such as problem solving, teamwork, critical thinking, and creativity.

All you need to run an invention club is a large room, some tables, some basic tools, and some low-cost materials. The resources in this guide and on the *Design Squad* Web site make it easy to facilitate a club and engage kids in invention and engineering.

STARTING AN INVENTION CLUB

Recruit club members

- Create a “Coming Soon” bulletin board and post a flier about the club.
- Advertise the club in your organization’s newsletter. Tell families about the challenges that kids will do and how to sign up their kids.
- Determine the number of kids you feel comfortable managing (we suggest 8 to 12 per leader). If more sign up, get more leaders, divide the club into two sessions, or keep a waiting list for the next time you offer the club.

Schedule the dates and arrange a meeting place

- Decide how many weeks your club will meet and the duration of each meeting. (We recommend at least an hour for five or six sessions.) Then select and reserve a space that has ample room and tables for materials. A place to store kids’ work is also helpful.

Give your room an invention club look and feel

- Tear out the posters in this guide and hang them in your clubroom.
- Make a bulletin board and post photos of kids doing the challenges so others can see what goes on at invention club meetings.
- For more ideas on how to give your room an “invention” look and feel, see page 2.

Partner with inventors and engineers

- Invite inventors and engineers to talk about everyday examples of inventing and engineering. The guests will serve as role models and can introduce kids to career options. To find volunteers, contact local universities and colleges with engineering programs. Also try manufacturing plants and public works and water departments. In addition, the *Design Squad*, InvenTeams, and Lemelson Center Web sites list engineering societies that can recommend potential partners. (See page 42.)
- Show video clips of engineers and kid inventors talking about how they became interested in engineering and inventing and the rewards of being an engineer. Get the D-Squad ProFiles at pbs.org/designsquad/profiles and InvenTeams profiles at web.mit.edu/inventeams/about.html.

WHY A CLUB?

An invention club draws kids who are interested in (or who might want to check out) invention and engineering. It gives them a defined time to do the guide’s activities, refine their designs, and even develop their own inventions.



CONNECT YOUR KIDS WITH INVENTEAMS

There are InvenTeams at schools throughout the country. If one’s nearby, connect your kids with what’s going on there. To find the nearest one, visit web.mit.edu/inventeams.

CHALLENGE 1

CONFETTI LAUNCHER



SHOW KIDS THE
RELATED TV EPISODE



Photo: Mika Tomczak

The perfect pancake? In the “Batter Up” episode, watch the Design Squad teams seek the right “ingredients” for a machine to cook, flip, and serve up delicious flapjacks at the flick of a switch. Watch the “Batter Up” episode online at pbs.org/designsquad.

Creativity and flexible thinking are useful in every phase of the invention process.

The invention challenge

Invent a device that launches a spoonful of confetti into the air. The bigger the cloud, the better.

In this challenge, kids: (1) play a creative-thinking game; (2) discuss the need for a confetti launcher; (3) brainstorm ways to launch confetti; (4) follow the design process to build a working prototype.

1 Prepare ahead of time

- Read the leader notes and the challenge sheet.
- Set up a testing zone—a large (e.g., 10x10 or 10x14-foot) tarp on the floor with an “X” taped in the center. Also have brooms and dustpans on hand.
- Gather the materials (per pair):
 - paper confetti
 - 1 straw
 - 2 sheets of cardboard (approx. 8.5 x 11 in.)
 - duct tape
 - 1 wooden spool
 - 4 paint stirrers
 - 4 rubber bands
 - 2 8-oz. paper cups
 - 2 4-oz. paper cups
 - string

2 Warm up: Play a game to promote creative thinking (10 minutes)

Making imaginative connections is useful in the invention process. Today’s game uses associations to help kids practice flexible, creative thinking. The game will also help kids focus on items that can be launched.

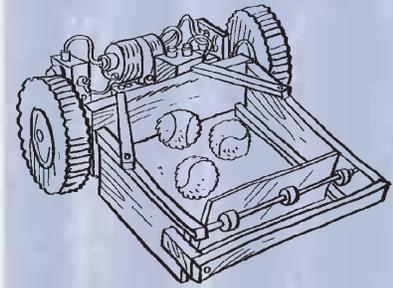
To play, say aloud the words: *rocket, water balloon, ship, shot put, new business, javelin, torpedo, and satellite*. Pause briefly between each word. Ask kids to guess what these things have in common. (They’re all *Things That Are Launched*.) The first kid to name the category runs the second round. Whisper the new mystery category to your winner—*Things at a Party*. Ask him or her to think up things at a party and say them aloud. The first kid to name the category wins and runs the final round, using the category *Things That Come in Small Pieces*. Play as in Rounds 1 and 2. Finally, tell the group the name of an item that fits all three categories—*confetti!*

3 Introduce the challenge (5 minutes)

To grab kids’ attention, read the following story.

People getting covered in litter and loving it? A huge mess and no one cares? What’s going on? It’s confetti. People love huge clouds of the stuff! And inventors have figured out ingenious ways to launch tons of confetti at events, such as parades, sports games, and circuses. They’ve used things like cannons, giant fans, and spring-loaded launchers. Why? Celebrating is important to people, and confetti makes an occasion or event more fun and exciting. Inventors are always looking for ways to improve things or meet people’s needs. A big burst of those little bits of paper makes almost anyone smile. The most confetti ever launched at a single event was at a New York City parade—11 million pounds (equal to the combined weight of 110,000, 100-pound kids)! That’s a lot of smiles!

SHOW KIDS A RELATED
INVENTEAM PROJECT



To help people improve their tennis game, the Essex High School InvenTeam invented a robotic tennis ball retriever. It collects the loose balls and drops them into a base station, which serves them up to the player. Check out this project and others at web.mit.edu/inventeams.

4 Brainstorm design ideas (10 minutes)

To help kids brainstorm, show them the materials, discuss the questions below, and have them sketch some design ideas.

- What are some things that make a cloud of confetti impressive? (*When the cloud is large, falls slowly, lasts a long time, includes a noisemaker, or has special shapes, such as little hearts for Valentine's Day*)
- Name some devices that launch objects into the air. (*Catapults, slingshots, squirt guns, fertilizer or seed spreaders, water balloon launchers, sprinklers, trampolines, etc.*)
- How do these devices develop the force they need to launch things? (*Objects can be blasted or thrown into the air using water pressure, air pressure, springs, elastic bands, static electricity, levers, electric or fuel-operated motors, etc.*)
- Look at the materials. What can you use to launch confetti into the air? (*Slingshots made from rubber bands and paper cups; catapults made from paint stirrers and rubber bands; and levers used like a seesaw made from paint stirrers and wooden spoons*)



During testing, we ended up with a variety of designs, such as catapults and slingshots. These pictures show several possible solutions. But don't show them to kids—they're likely to copy the ideas they see in the pictures.

5 Build, test, and redesign (25 minutes)

In our testing sessions, kids had a blast launching confetti. The laughter and excitement was contagious. Our sessions also yielded a few dos and don'ts:

- **Avoid using balloons**—In our testing, some kids couldn't resist popping the balloons to scare their friends. Others just filled balloons with confetti and said they were done. Also, balloons aren't good launchers. The confetti only comes out when you point the balloon's opening down. And then the confetti falls to the floor without making much of a cloud.
- **Avoid metallic confetti**—This shiny material sticks to everything. Use paper confetti, instead, to make cleanup easy.
- **One teaspoon of confetti per launch is plenty**—It produces a satisfying burst but not an unmanageable mess.
- **Define a testing zone**—Have kids launch confetti only when standing on the "X" in the middle of the tarp, even if it means waiting in line. Our tarp was 10x14 feet. A big tarp and clear ground rules will facilitate cleanup.



CHALLENGE THE STEREOTYPE

Tell kids that inventors and engineers get involved in all sorts of fun, interesting projects that make people's lives more enjoyable. For example, point out that celebrating is important to people, and engineers and inventors have figured out many ways to launch confetti to make events more fun and exciting. Also show kids videos in which young engineers describe how engineering lets them lead interesting, exciting lives and do cool things. See them online at:

- pbs.org/designsquad/profiles
- web.mit.edu/inventteams/videos.html

6 Discuss what happened (10 minutes)

To learn about an idea's strengths and weaknesses, inventors build a series of early designs called *prototypes*. Ask kids to present, compare, and discuss the prototypes they built today.

- Who might use a confetti launcher? (*Moviemakers; people running theaters, arenas, and circuses; and people at parties, parades, sports events, and weddings*)
- How does your launcher develop enough force to launch confetti? (*It stores energy [potential energy], which, when released [kinetic energy], sets the confetti in motion. The force can come from things like stretched rubber bands that get released or from hitting the end of a lever, set up like a seesaw.*)
- Which design launched the biggest cloud of confetti? How did that design generate its force?
- How could you change your launcher's design to launch confetti made from something other than paper bits? For example, streamers, corkscrew confetti that twirls down like a helicopter, mini-parachutes, fake money, dried flower petals, fake snow, and foam peanuts.

TINKER SOME MORE

As you've just discovered, launched confetti is messy. Brainstorm a list of clean-up machines or have kids imagine a vehicle dedicated to confetti collection.

- What are some ways to pick up huge amounts of paper bits at large events, like a championship sporting event, convention, or a ticker-tape parade?
- How could a collection vehicle use plows, vacuums, fans, leaf blowers, or balloons charged with static electricity?
- Test to see if rakes or brooms work better. (*The Department of Sanitation, New York City uses mechanical brooms and handheld rakes.*)

To learn about an idea's strengths and weaknesses, inventors build a series of early designs called prototypes.

CONFETTI LAUNCHER



as built on TV.
pbs.org/designsquad

People are always looking for ways to make an event more fun. What's more fun than confetti? Once it comes raining down, you can't help but smile.



Confetti is used at theaters, the circus, parties, parades, and sports events. But how do you launch it?

All right, I want you to INVENT a confetti launcher.

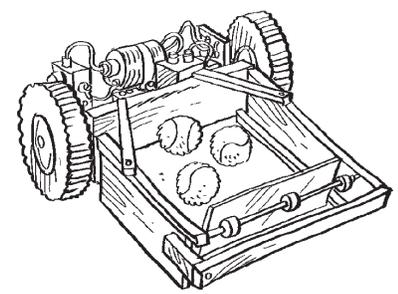
Let's review the specs. It's got to be easy to use. And it's got to send the confetti high—the bigger the cloud, the better!

MATERIALS

Let's look at your materials. What can you use to launch confetti?



LET'S GET TO WORK!



To help people improve their tennis game, the Essex High School InvenTeam invented a robotic tennis ball retriever. It collects the loose balls and drops them into a base station, which serves them up to the player. Check out this project and others at web.mit.edu/inventeams.



PBS. Watch DESIGN SQUAD on PBS or online at pbs.org/designsquad.

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CHALLENGE 2 GET-MOVING GAME



SHOW KIDS THE RELATED TV EPISODE



To help basketball fans see all the angles of a fast-moving game, the Design Squad teams compete to design a system of courtside remote-controlled cameras. Watch the “Got Game” episode online at pbs.org/designsquad.

The invention challenge

Invent an indoor game for one or two people that gets you moving.

In this challenge, kids: (1) play an “imagine new uses for old things” game; (2) brainstorm activities that get people up and moving; (3) follow the design process to invent a game, including the equipment and rules for playing it.

1 Prepare ahead of time

- Read the leader notes and the challenge sheet.
- Gather the materials (per ten kids, organized into five teams):
 - 20 rubber bands
 - 10 Ping-Pong balls
 - 10 plastic spoons
 - 5 paint stirrers
 - 5 tennis balls
 - 20 sheets of cardboard (approx. 8.5x11 in.)
 - 10 small aluminum baking tins
 - 5 small plastic bags
 - duct tape
 - scissors
 - copier paper
 - string

2 Warm up: Play an “Imagine New Uses For Things” game (10 minutes)

Ask kids this seemingly simple question: What’s an invention? Kids are likely to say it’s a new machine or product. But sometimes, inventing means coming up with a new use for an existing product. To encourage flexibility in kids’ thinking, ask them to think of non-electric things used in a kitchen (e.g., spatula, strainer, pot, pan, ladle, cup, wooden spoon, pitcher, refrigerator magnet, mixing bowl, paper towel, etc.). (NOTE: Don’t let kids choose a knife or other sharp, pointy object as their implement.) Then, have each kid think up a game or sport that could use these. Since this is a thought exercise rather than an actual game, encourage kids to be imaginative. Once they finish brainstorming, have each kid briefly describe the game or sport he or she invented. Point out that looking at things in new ways takes imagination, and imagination and invention go hand in hand, whether you’re an artist, a toolmaker, a housekeeper, an inventor, or an engineer.

3 Introduce the challenge (5 minutes)

To underscore the need for inventions that promote physical activity, introduce kids to the idea of a “couch potato.”

Do you know a couch potato—someone who watches a lot of TV? A group of Girl Scouts in Fremont, California wanted to help couch potatoes have a lot of fun living healthier, more active lives. So they created the Couch Potato Interest Project. To earn a badge, you need to do several activities. One is to check out a few health studies. Many studies show that people who are inactive risk being overweight, becoming depressed, and having poor fitness and out-of-control blood-sugar levels (diabetes). Another activity is to keep a log of how much TV you watch and see if you watch more or less than your friends. Then, you quit watching TV for a week. At the end of the week, you evaluate how you feel. Do you feel better? Healthier? Happier? Were you more active? These girls invented a badge to help couch potatoes. What are other inventions that could help improve a couch potato’s life?

COUCH POTATO?

The term *couch potato* was coined (i.e., invented) in 1976 and entered into the Oxford English Dictionary in 1993. Research studies consistently show that being sedentary can lead to health problems—obesity, poor nutrition, diabetes, depression, and poor fitness.

SHOW KIDS A RELATED INVENTEAM PROJECT



The Divine Child High School InvenTeam invented a way for people to recharge up to three electronic devices, such as cell phones and MP3 players, while riding a bike. Check out this project and others at web.mit.edu/inventeams.

4 Brainstorm design ideas (10 minutes)

- This challenge is about action. List a few action verbs on the board (e.g., toss, roll, throw, catch, shoot, spin, and paddle). Challenge kids to add to the list (e.g., hit, run, block, flip, dribble, knock over, sink, pitch, steer, and score). Finally, ask kids to match each verb to a game (e.g., *hit* and *baseball*).
- To get kids thinking about games that are fun and easy, ask, What games might you play at recess, camp, or a carnival? (*four square, tag, tug-of-war, ring toss, hit-a-target, jump rope, beanbag toss, mini golf, knock down a milk-jug tower, balloon pop, basketball, etc.*)
- Discuss what it means to invent a game. Does it require a new piece of equipment? New rules? Changing a familiar game? (*It could be any or all of these things.*)



Looking at things in new ways takes imagination, and imagination and invention go hand in hand.

During testing, we ended up with a variety of designs. These pictures show several possible solutions. But don't show them to kids—they're likely to copy the ideas they see in the pictures.

5 Build, test, and redesign (25 minutes)

In our testing, the kids loved playing their games—a true measure of success. During our sessions, we encountered some issues that your kids might also face:

- **Kids can't think of a game.** Revisit the list of verbs and games. In our testing, kids' games usually involved catching, throwing, bouncing, dropping, knocking down, or rolling. Also, kids can choose an existing game from the brainstormed list and change it: a new part, a new element from another game, or new rules, for example.
- **Your space is small for active games.** You may need to tell kids that their games need to be playable in a certain amount of space. Tell kids how much room each pair can have.
- **The game is very complicated.** Have kids focus on one part of their game instead of trying to do everything they have in mind. As a guideline, ask them to choose a part that kids could play at recess or at a carnival booth.

6 Discuss what happened (10 minutes)

- Is a game that increases people's activity level a good invention? Explain. (*An active game provides exercise, which benefits people in ways such as improving health and mood.*)
- How does your game get people moving?
- What features of your game would make someone want to play? (*The game is fun, not too easy or hard, and has simple rules and different levels of play.*)
- Testing and redesigning are important steps in the design process. How did these steps help you invent your game? (*Kids start with a particular rule or piece of equipment. Sometimes, they realize that the rules don't really work, and they modify them. Other times, the equipment doesn't work as expected, and kids modify it or change the rules to play the game with the equipment as is. This sort of testing and redesigning often happens on the fly, but it's still the design process that leads to an improved invention.*)

TINKER SOME MORE

Tell kids they work for a company that's been asked to invent a game that helps one of the following users be more active. What kind of game ideas can they suggest for people who are:

- on crutches or in a wheelchair?
- who are bedridden?
- on a long road trip?
- living on the International Space Station?

CHALLENGE THE STEREOTYPE

Tell kids that inventors and engineers do interesting things that improve people's lives. For example, point out that engineers and inventors have developed many ways to increase people's activity level and improve their health and level of fitness. Also show kids videos in which young engineers describe how engineering lets them lead interesting, exciting lives and do cool things. See them online at:

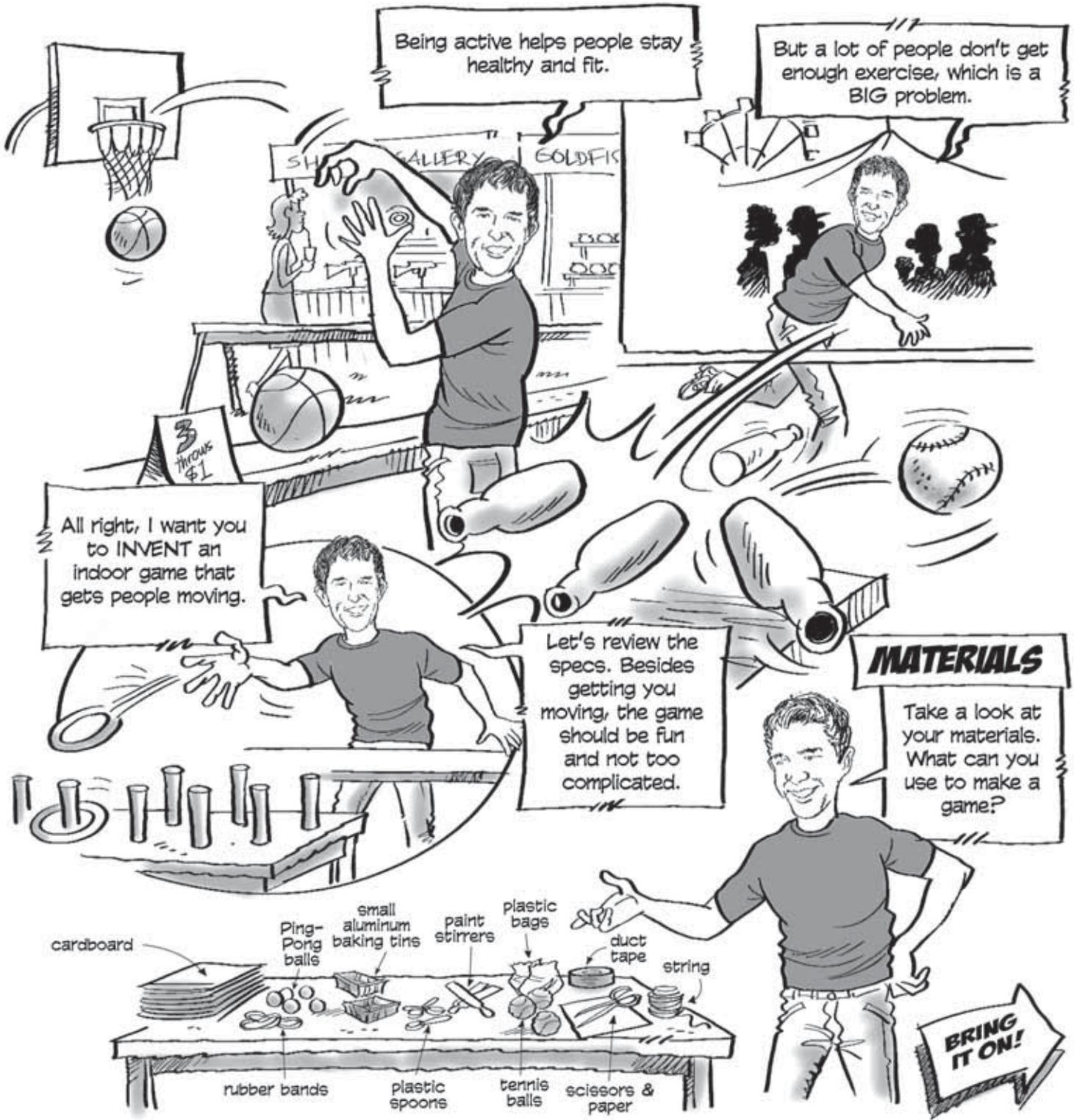
- pbs.org/designsquad/profiles
- web.mit.edu/inventeamsvideos.html

GET-MOVING GAME



as built on TV.

pbs.org/designsquad



BRAINSTORM & DESIGN

- What are some words that describe action?
- What games do I play at recess or at a fair?
- What equipment will my game need?



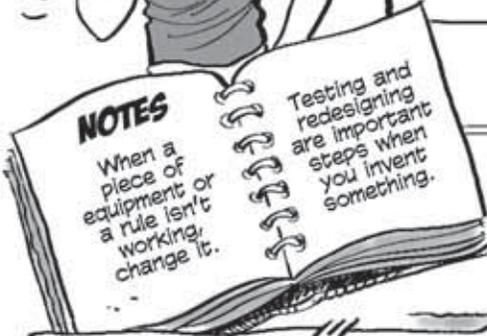
BUILD

Lookin' good. How can your game work better? Will it stand up to lots of use?



TEST & REDESIGN

Cool game, but complicated. Is there a way to simplify it?



Good stuff. Being active helps improve your health, mood, and fitness. You invented something that makes people's lives better, which is what invention and engineering are all about.



The Divine Child High School InvenTeam invented a way for people to recharge up to three electronic devices, such as cell phones and MP3 players, while riding a bike. Check out this project and others at web.mit.edu/inventeams.



PBS. Watch DESIGN SQUAD on PBS or online at pbs.org/designsquad.

Invent It, Build It is funded by
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the **Lemelson foundation**
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Additional funding for *Design Squad* provided by



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CHALLENGE 3 HARMLESS HOLDER

SHOW KIDS THE
RELATED TV EPISODE



Photo: Parrish Kennington

To help out a group that runs an urban farm, the Design Squad teams compete to design the best compost lifter. Watch the "Green Machines" episode at pbs.org/designsquad.

Inventors and engineers work to make the world a better place.

The invention challenge

Invent a holder for six cans that's animal-safe, sturdy, convenient, and easy to carry.

In this challenge, kids: (1) learn why discarded plastic rings can be a problem for wildlife; (2) examine plastic six-pack holders; (3) brainstorm animal-friendly ways to package six cans; and (4) follow the design process to invent a solution to the challenge.

1 Prepare ahead of time

- Read the leader notes and the challenge sheet.
- Get one or two plastic six-pack rings.
- Gather the materials (per team):
 - 6 full cans of soda, seltzer, or juice
 - duct tape
 - cardboard (approx. 8.5x11 in.)
 - wax paper
 - copier paper
 - string
 - 4 paint stirrers
 - 6 rubber bands
- Have sponges and towels on hand in case of spills.



2 Introduce the challenge (5 minutes)

To grab kids' attention, read the following story.

It was getting all too common along the beach where she lived. Birds and turtles washing up on shore, tangled in the plastic rings used to hold drink cans together. Up ahead was just such a bird. Fortunately, it would live. With a snip of the girl's scissors, the plastic ring that was strangling the bird fell off. You know those plastic rings, the ones for carrying packs of soda cans. They may be strong, light, and easy to carry. But the trouble begins when they become trash.



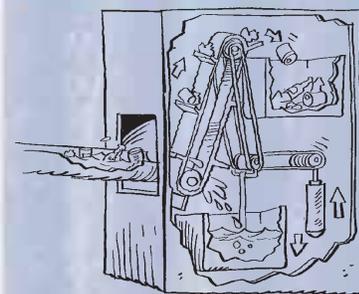
Birds, turtles, fish, and other sea creatures get tangled up in the rings of plastic beverage holders.

3 Warm up: Check out a plastic holder (10 minutes)

Pass around some six-pack holders and ask:

- How strong are the rings? How big? How stretchy? How easy to use?
- What are some advantages and disadvantages of plastic? (*Plastic is strong, waterproof, lightweight, easily molded, flexible, durable, and inexpensive. But when it's thrown in the trash, it never biodegrades, as paper, string, and wood do.*)
- Who would benefit from, or be interested in, having safe six-pack holders? (*Animals, of course, and manufacturers who want to offer a safe product, environmentalists, animal-rights groups, and consumers who buy "green" products*)

SHOW KIDS A RELATED
INVENTEAM PROJECT



Storm water often contains debris, which can clog storm drains. More than an expensive problem, a clogged drain can be a health hazard. The Colfax High School InvenTeam invented a drain that separates out the debris and puts it into a trash can. Check out this project and others at web.mit.edu/inventeams.

Tell kids that animals get tangled in these plastic rings and can't get free. To have them experience this situation, have each kid slip a rubber band loosely onto his or her right wrist. Ask kids to try to remove it, using only their right hand. No fair using another body part, such as teeth or their left hand!



4 Brainstorm design ideas (10 minutes)

To help kids brainstorm, show them the materials, discuss the questions below, and have them sketch some design ideas.

- The cans in a six-pack are all the same size and shape. Name some other containers that hold objects that are the same size and shape. (*Egg cartons, beverage trays, fruit cartons, a cash register drawer, tool racks, pencil holders, etc.*)
- You need to be able to carry the cans easily. What are some different kinds of handles used to pick up objects? (*Luggage handles, backpack straps, wheelbarrow handles, tops of milk cartons, etc.*)
- Do the cans have to sit in two neat rows of three? (*No. Kids can stack their cans or set them on their sides.*)
- How can you keep cans together? (*You can tie them together, loop them with rubber bands, stick them with tape, or set them on a tray made of cardboard or paint stirrers.*)
- How will you take one can out of your holder while still keeping the other five cans together? (*Leave an opening or make a way to pull the cans apart.*)
- Cans are heavy and will put a lot of force—pushes and pulls—on your holder. What are some ways a holder can resist such force? (*Using sturdy materials, reinforcing the joints where parts join together, and reinforcing the places where the cans put stress on the holder*)



During testing, we ended up with a variety of designs. These pictures show several possible solutions. But don't show them to kids—they're likely to copy the ideas they see.

CHALLENGE THE STEREOTYPE

Tell kids that inventors and engineers work to make the world a better place. For example, point out that being “green” is important to people and that engineers and inventors look for ways to improve packaging systems to reduce litter and the need for raw materials as well as eliminate dangers to animals and the environment. Also show kids videos in which young engineers describe how engineering lets them lead interesting, exciting lives and do cool things. See them online at:

- pbs.org/designsquad/profiles
- web.mit.edu/inventteams/videos.html

5 Build, test, and redesign (25 minutes)

To learn about a design’s strengths and weaknesses, inventors build a series of early designs called *prototypes*. During the building and testing of their prototypes, here are some problems your kids might face:

- **Six cans are too heavy for a design.** Even though a kid may have a good idea, it still may not support six full cans. Kids can strengthen their designs by reinforcing the sides or corners with cardboard, adding a layer of tape, or cutting slots and inserting materials into the slots.
- **The holder collapses when a can is removed.** Some designs use cans as part of the support system. When a can is removed, the holder caves in. Point out what’s happening and encourage kids to find ways to strengthen the holder so it doesn’t rely on cans.
- **A can opens.** We had spare cans for kids to use. We also had towels and sponges to wipe up any spills.
- **Kids want to drink the soda.** If you don’t want kids to drink, tell them you need the cans for another session or use cans of a drink they probably won’t like, such as tonic water or seltzer.

6 Discuss what happened (10 minutes)

Ask kids to present, compare, and discuss the prototypes they built today.

- Which features worked best for holding cans together? Picking them up? Carrying them?
- Which design is sturdiest? Lightest? Simplest? Uses the fewest materials?
- Your design had to withstand bending, twisting, and pushing. How well did your design resist these forces?
- What are some ways an improved holder could help the environment? (*An improved holder reduces litter, eliminates a danger to animals, and, if the design is reusable, reduces the need for raw materials.*)
- If an animal were to eat some of the materials you used today, it might still cause problems. How are these problems similar to or different from the problems caused by plastic six-pack holders?

TINKER SOME MORE

As a follow-up or fun at-home project, ask kids to draw a design of a boat that skims trash off the surface of a river, lake, or ocean. Have them label the parts and give their invention a catchy name.

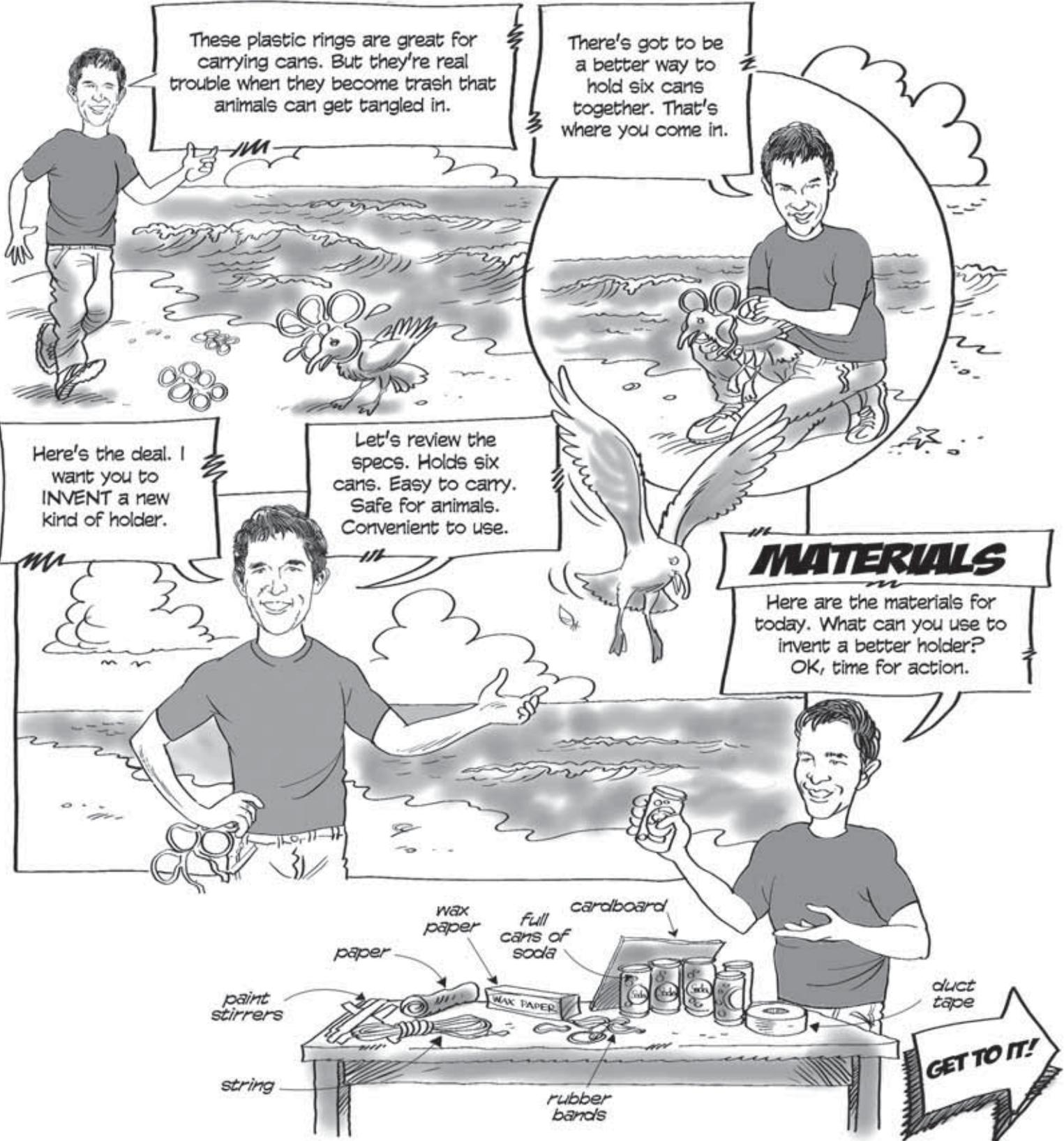
- What kind of vessel could do the job?
- What parts would it have?
- How would it move?
- How could it tell the difference between trash and other objects, such as animals and seaweed?
- How would it store and dump the trash?
- Could your machine double as a beach sweeper, sifting trash from sand? Explain.

HARMLESS HOLDER



as built on TV.

pbs.org/designsquad



BRAINSTORM & DESIGN

- How can I hold six cans together?
- Should I arrange the cans on end? On their sides? Stack 'em?
- How will I remove the cans easily?
- How will I carry the holder?

BUILD

What've you got so far?
Hmmm, how are you going to keep the cans from falling off?
Any plans for using other materials?

TEST & REDESIGN

Okay, show me what you've got. Oops, you need a better handle. Back to the drawing board.

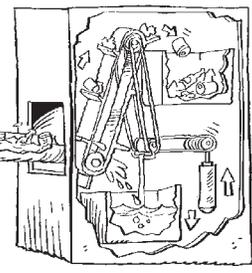
NOTES

My holder's bending and twisting. That's **FORCE** at work: pushing and pulling on the parts.

Need to reinforce things to resist the force.

LATER...

Congratulations! You did an incredible job. You improved things for animals, helped reduce litter, and made the world a better place. That's what invention and engineering are all about.



Storm water often contains debris, which can clog storm drains. More than an expensive problem, a clogged drain can be a health hazard. The Colfax High School InventTeam invented a drain that separates out the debris and puts it into a trash can. Check out this project and others at web.mit.edu/inventteams.



PBS. Watch DESIGN SQUAD on PBS or online at pbs.org/designsquad.

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CHALLENGE 4 SPEEDY SHELTER



SHOW KIDS THE
RELATED TV EPISODE



Photo: Mika Tomczak

The Design Squad teams take a crash course in pre-industrial building techniques as they compete to build 20-foot bridges without the aid of power tools, forklifts, or flushable toilets. Watch the “DS Unplugged” episode at pbs.org/designsquad.

The invention challenge

Invent an emergency shelter that can fit a person and is sturdy and quick to build.

In this challenge, kids: (1) think about a familiar shape in new ways; (2) learn about an injured hiker who survived by building a makeshift shelter; (3) brainstorm shelter designs; (4) follow the design process to invent a solution to the challenge.

1 Prepare ahead of time

- Read the leader notes and the challenge sheet.
- Get paper and pencils for the warm-up activity.
- Gather the materials (per team):
 - 2 cardboard sheets (approx. 8.5x11 in.)
 - 3 33- or 42-gal. garbage bags, cut open into sheets
 - 16 3-ft. bamboo plant stakes
 - scissors
 - duct tape
 - string

NOTE #1: The bamboo plant stakes (available at garden centers and hardware stores) come in various lengths. The 3-foot length is the best for this challenge.

NOTE #2: Don't use fiberglass stakes. If a kid lets go of a bent fiberglass stake, it will immediately straighten. Kids could be hurt if an end that's whipping through the air hits them.

NOTE #3: As a safety measure, cut the garbage bags open into sheets before the session. This way, kids can't get stuck inside a bag and risk suffocation.

2 Warm up: Spark kids' imaginative thinking (10 minutes)

Draw a triangle on a board and show kids how it can be turned into an object (see examples at right). Next, have kids draw eight triangles on a sheet of paper, leaving some space around each one. Challenge them to turn their triangles (or pairs of triangles) into objects. After a minute or two, have kids share their ideas. Tell them inventors think about things in new ways and see interesting possibilities.



3 Introduce the challenge (5 minutes)

Put today's challenge in context by reading the following news story.

It started as a pleasant hike. But soon John Balgrano was in trouble. While hiking alone in the mountains of New Zealand, he slipped and fell down a mountainside, injuring his leg so badly he couldn't walk. Plus he'd lost his camping gear in the fall. That night, a storm blew in, bringing high winds, freezing temperatures, rain, and hail. Balgrano needed shelter—fast. He grabbed branches, strips of bark, and leaves and did his best to turn them into a weatherproof roof. Then he waited, growing colder and weaker throughout the stormy night. Twelve hours later, just as he was slipping into what he called the “jaws of death,” a search party rescued him.

In this challenge, kids explore how shapes, such as triangles, can be used to make a stable structure. As a warm-up, kids stretch their imaginations by turning triangles into something different.

SHOW KIDS A RELATED INVENTEAM PROJECT



Norfolk Technical Vocational Center's InvenTeam invented an ergonomic backpack that reduces the strain on a person's back. Check out this project and others at web.mit.edu/inventeams.

4 Brainstorm design ideas (10 minutes)

To help the kids brainstorm design ideas, tell them today's challenge and ask:

- How could you use different parts of plants to make a shelter that would be strong enough to withstand the wind and rain? (*Use long, sturdy branches and large leaves to block the wind and rain. Weave them together or layer them.*)
- Besides hikers, who else might use such a shelter? (*People who are homeless, stranded at sea, shipwrecked, or affected by natural disasters, such as hurricanes and earthquakes*)
- Buildings have to resist forces like the pushes and pulls caused by gravity and wind. What are some ways engineers help create sturdy buildings? (*They make sure that the structure has a solid base, the materials are strong enough, and the parts are securely fastened together.*)
- In addition to triangles, what shapes are good when building structures and why? (*Cubes, squares, rectangles, pyramids, domes, cylinders, and arches. They distribute force, such as the weight of the roof, among different parts of the frame. Triangles, domes, and arches are particularly strong shapes because they spread the force to nearly every other part of a frame.*)
- How can you make a wobbly frame more stable? (*Make sure each part is connected to, and supported by, two or more other parts.*)
- Tents have three basic parts: a frame, a cover, and connectors to hold the parts together. Look at the materials and sketch at least three shelter designs. (*An effective design will be similar to "skin and skeleton" structures, such as a tent or skyscraper. The skeleton is the frame [e.g., the pole or steel frame] and the skin is the covering material [e.g., fabric or glass]. Some structures, such as large tents and radio towers, use wires for added stability.*)

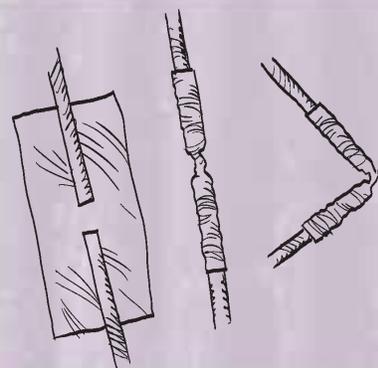


During testing, we ended up with a variety of designs. These pictures show several possible solutions. But don't show them to kids—they're likely to copy the ideas they see.

5 Build, test, and redesign (25 minutes)

During testing, we encountered some problems that your kids might also face:

- **Connecting parts together is hard**—Make strong, flexible joints with duct tape (see illustration).
- **The frame tilts or twists**—One way to strengthen a frame is to connect each part to one or more other parts. Also, kids can brace the corners of their frame with cardboard. Or, they can run a bamboo stake at an angle between two parts of the frame. This creates a triangular brace, which adds rigidity to a frame.
- **The frame wobbles**—To increase stability, anchor the frame to the floor with tape, or secure it by running lengths of string from the frame to the floor and taping them down.
- **The roof collapses the frame**—Remind kids that the plastic roof will push down on the top of the frame. Have them simulate this force by pushing down gently on the top of the frame. Reinforce the frame as necessary.
- **The plastic slides off**—Have kids tape two or three plastic sheets together before draping it over the frame. Once in place, they can secure the cover with tape or string.



To connect two plant stakes, lay a 3-inch length of duct tape on the floor, sticky side up. Lay the ends of the plant stakes on the tape, keeping a ½-inch gap between them. Close the tape over the ends of the two stakes. Now the tape can act like a hinge.

6 Discuss what happened (10 minutes)

Ask kids to present, compare, and discuss their designs.

- What force affected your shelter the most? (*Gravity—including the weight of the frame, plastic, and any objects placed on the tent*)
- What tent shapes seemed to be the strongest? (*Triangles and domes are particularly strong shapes because they spread the force to nearly every other part of a frame.*)
- What were some successful strategies for making your shelter more stable? (*The base was securely attached or weighted down to the ground, the frame is a stable shape, and the parts were reinforced where they join together.*)
- What design changes would make your shelter easier to use or more useful in an emergency? (*Making it more portable by reducing the size and weight; making it easier to put up and take down; and making it a bright color so rescuers can see it.*)

TINKER SOME MORE

- (1) Show kids the D-Squad ProFile of engineer Connie Yang who designs tents and talks about how engineering lets her combine a passion for sports with a love of solving interesting problems. Watch it online at pbs.org/designsquad/profiles/connie_yang.html.
- (2) Challenge kids to make a shelter that:
 - is small enough to fit in a backpack,
 - takes only one person to set up,
 - doesn't require tools to put together,
 - can be collapsed and used again.

CHALLENGE THE STEREOTYPE

Tell kids that inventors and engineers enjoy solving problems about things that really matter to people. For example, they develop handy, inexpensive, weatherproof shelters for hikers and for people who are homeless, stranded at sea, or affected by natural disasters, such as hurricanes and earthquakes. Also show kids videos in which young engineers describe how engineering lets them lead interesting, exciting lives and do cool things. See them online at:

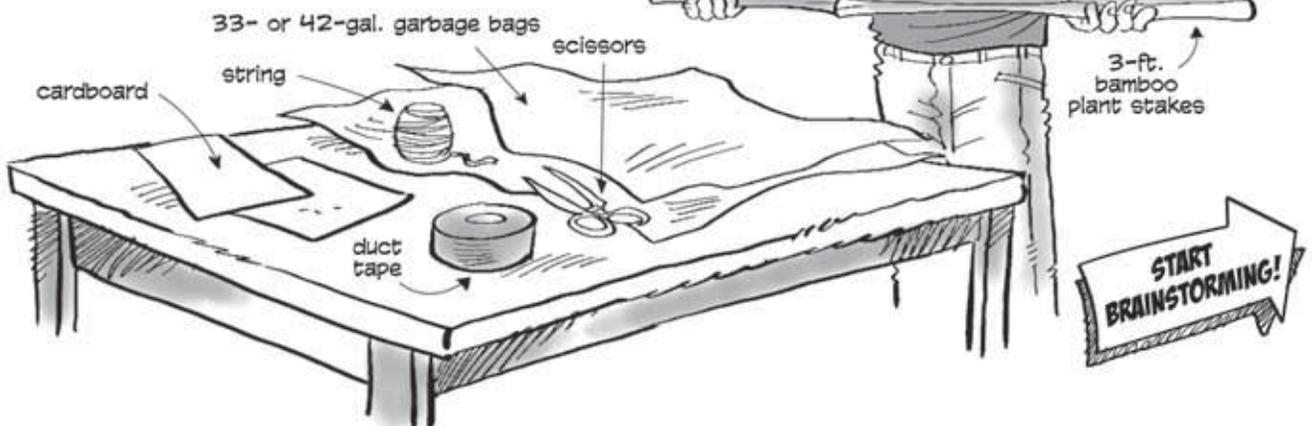
- pbs.org/designsquad/profiles
- web.mit.edu/inventteams/videos.html

SPEEDY SHELTER



as built on TV.

pbs.org/designsquad



BRAINSTORM & DESIGN

- Ask yourself, How will I:
- make a sturdy frame?
 - connect the poles together?
 - attach the cover to the frame?

BUILD

What've you got?
Looks like getting in and out may be tricky. And remember, in an emergency, there's no time to deal with lots of parts.

TEST & REDESIGN

Ready to test? Hmm, how can you stop the frame from wobbling?

LATER...

Good stuff. Your shelter protects people and is handy and affordable. Plus, you invented something people really need, which is what invention and engineering are all about.

NOTES

Cross-braces turn squares into triangles. Triangles are strong because all three sides carry some of the load.

cross brace
In a square, only two sides support the load.

LEMELSON-MIT
InvenTeams
KIDS INVENT



Norfolk Technical Vocational Center's InvenTeam invented an ergonomic backpack that reduces the strain on a person's back. Check out this project and others at web.mit.edu/inventeams.



Watch **DESIGN SQUAD** on PBS or online at pbs.org/designsquad.

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CHALLENGE 5 CONVENIENT CARRIER



SHOW KIDS THE
RELATED TV EPISODE



Photo: Helen Tsai

To help an aquatic dancer who's also an amputee, the Design Squad teams compete to design leg and hand prostheses for an underwater performance. Watch the "Water Dancing" episode online at pbs.org/designsquad.

Inventors are good at spotting problems and figuring out solutions.

The invention challenge

Invent a convenient way for someone using crutches or a wheelchair to carry small personal items.

In this challenge, kids: (1) experience some of the obstacles people on crutches face; (2) brainstorm ideas for carriers; (3) follow the design process to invent a solution to the challenge.

1 Prepare ahead of time

- Read the leader notes and the challenge sheet.
- Gather the materials (per session):
 - 1 armchair (represents a wheelchair)
 - crutches (at least one pair; more, if possible)
 - 4 cardboard sheets per team (approx. 8.5x11 in.)
 - 20 8-oz. paper cups
 - copier paper
 - rubber bands
 - string
 - duct tape
- To stand in for fragile personal items (e.g., a cell phone, remote control, glasses, and music player), collect items such as a book, pack of index cards, paper cup, CD case, soda can, deck of cards, and keys for kids to use.

2 Warm up: Do a "Life on Crutches" experience (10 minutes)

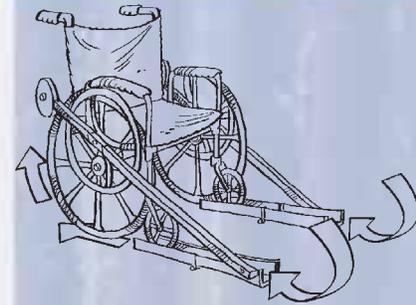
Have kids experience some of the obstacles people on crutches face. If possible, use actual crutches. But you can do the following to simulate using crutches. Give each kid two magazines, newspapers, or pieces of paper. Have them place the objects under their upper arms, holding them in place by pressing their upper arms to their body. Then ask kids to stand on one leg. This awkward posture simulates how much a pair of crutches affects one's movement. Next, hand each kid a lunch tray or flat sheet of cardboard. Place a paper cup on it. Have them pass the cups back and forth, keeping the crutches (or papers) in place. Ask them to take five steps (hops, really), holding the tray and not letting the cup fall. Collect the materials and have the kids sit down. Discuss what simple tasks would be hard or impossible to do on crutches? (*Talk on a cell phone, shake hands, drink a soda, tie shoes, carry objects, get onto a bus, go up stairs, etc.*)

3 Introduce the challenge (5 minutes)

To get kids focused on the need for devices to improve the lives of people living with disabilities, read the following news story.

One moment, teenager Carlana Stone was a gymnast and cheerleader. The next moment, she was destined for life in a wheelchair. After a car accident, both her legs were permanently paralyzed. Using only her upper body, she learned how to take showers, open doorways, and get in and out of cars and bed. Through her determination, Carlana learned to do far more difficult tasks. Even without the use of her legs, she became a skydiver, skier, scuba diver, and airplane pilot! Professionally, she landed a job as a TV reporter, broadcasting stories from all over Miami, Florida while sitting in a chair.

SHOW KIDS A RELATED
INVENTEAM PROJECT



The Americans with Disabilities Act requires all curbs to have cutouts for wheelchairs; however, many don't. To help, the Ardsley High School InvenTeam invented a device that attaches to a manual wheelchair and enables it to climb a curb. Check out this project and others at web.mit.edu/inventeams.

4 Brainstorm design ideas (10 minutes)

People who use crutches or wheelchairs have their hands occupied much of the time. This can make it difficult to carry lots of small personal items. Inventors like solving this kind of problem because it addresses a real need and has many interesting solutions. Tell kids that today's challenge is to invent a carrier for an assortment of personal items to be used by people in wheelchairs or on crutches. To help them brainstorm design ideas, ask the questions below.

- What kind of stuff do people carry with them in their daily lives? *(Cell phone, glasses, music player, sunglasses, keys, book, snack, drink, CDs, cup, purse, remote control, wallet, etc.)*
- What are some different types of holders? *(Pencil holders, backpacks, pockets, cup holders, purses, pouches, cans and bottles, drawers, etc.)*
- How could these holders be adapted for use by people in wheelchairs or on crutches?
- Look at the materials for today's challenge and sketch some different carrier designs.



During testing, we ended up with a variety of designs. These pictures show several possible solutions. But don't show them to kids—they're likely to copy the ideas they see.

CHALLENGE THE STEREOTYPE

Tell kids that inventors and engineers think of creative ways to improve people's lives. For example, they develop carriers to help people using wheelchairs or crutches keep their personal items accessible and organized. Also show kids videos in which young engineers describe how engineering lets them lead interesting, exciting lives and do cool things. See them online at:

- pbs.org/designsquad/profiles
- web.mit.edu/inventteams/videos.html

5 Build, test, and redesign (25 minutes)

During testing, we encountered some problems that your kids might also face:

- **So many possibilities**—The number of options can overwhelm some kids. Should my carrier be for crutches or wheelchairs? Should it be specialized for particular items or used in general? Once we pointed out that each option would solve a problem and all were good ideas, they were able to choose a design and focus on building a prototype of it.
- **Carrier designs are all alike**—Carriers don't always have to attach to the wheelchair or crutch. In our testing, one kid designed a carrier that hangs around a person's neck.
- **Tray on the arm of a chair (or wheelchair) won't stay level**—A tray can sag or droop if it isn't firmly attached. To keep it level, have kids increase the amount of tray in contact with the chair's arm; position the tray so the chair's arm is closer to the middle; and use string, columns, or bracing to support the tray. Encourage kids to have the tray swing or lift out of the way to avoid making it hard to get in and out of the chair.

6 Discuss what happened (10 minutes)

Ask kids to present, compare, and discuss the prototypes they built today.

- How did experiencing what it's like to be on crutches influence your design?
- How easy is it to attach and remove your carrier?
- Which carriers are easiest for putting in and taking out the items?
- If your carrier fell off easily or was unsteady, how did you redesign it? (*Increased the area of the base, centered the weight, used stronger or tighter fasteners, etc.*)

TINKER SOME MORE

(1) Brainstorm ideas for improving the usability of wheelchairs and crutches.

- How can you modify crutches so they'll work on a muddy field?
- How could a wheelchair climb stairs or over obstacles?
- How could a person in a wheelchair be at eye level with a person who's standing?
- Design crutches with heated handles that can be removed in the summer.
- Design crutches that collapse for storage or easy carrying.
- Design a wheelchair with a sunshade.

(2) Visit the following Web sites and show kids innovative assistive devices:

- **The Hampshire College Lemelson Center**
hampshire.edu/lemelson
- **Junior Engineering Technical Society**
jets.org/programs/nedc/index.cfm

CONVENIENT CARRIER



as built on TV.
pbs.org/designsquad



BRAINSTORM & DESIGN

- What kinds of things will my carrier hold?
- What kinds of carriers do I use every day?
- Should my carrier be for crutches or for a wheelchair?
- How will I attach my carrier to the crutches or wheelchair?

BUILD

Ready? Remember, it should be easy to put things into and take things out of. You may also want to design pockets for specific items, like a cell phone or a cup.

TEST & REDESIGN

Hmmm. It's big, so it holds a lot. But it also gets in the way. And it keeps falling off. Time to redesign.

HINT

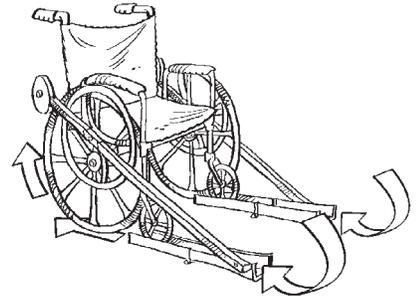
The crutch is a LEVER. By keeping the weight high, people won't have to swing extra weight out at the end of a lever, which is hard work.

Did you do it? Did you design a carrier that will help people using crutches or a wheelchair keep their stuff organized and within reach? Congratulations! Improving people's lives is what invention and engineering are all about.

LEMELSON-MIT

InvenTeams

KIDS INVENT



The Americans with Disabilities Act requires all curbs to have cutouts for wheelchairs; however, many don't. To help, the Ardsley High School InvenTeam invented a device that attaches to a manual wheelchair and enables it to climb a curb. Check out this project and others at web.mit.edu/inventeams.



PBS. Watch DESIGN SQUAD on PBS or online at pbs.org/designsquad.

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CHALLENGE 6

INVENT A BETTER WORLD

Congratulations! You've completed five invention challenges and helped spark your kids' inventive spirits. In the process, you've honed their creative problem-solving and tinkering skills, and taught them how to use the design process to think through a problem and come up with creative solutions.

Now it's time to have your kids apply their inventing skills to their own lives. Use the ideas below to help kids identify a need and then do something about it by devising an original solution.

FIND PROBLEMS TO SOLVE

Encourage kids to keep their eyes open for problems. Remind them that they don't need to look far. They can find opportunities to make improvements in their:

- community (animal shelters, grocery stores, shopping malls, recycling center, parks, etc.).
- school (lunch room, auditorium, playground, classroom, lockers, etc.).
- home (backyard, garage, bathroom, mailbox, kitchen, etc.).
- favorite activities (sports, music, reading, etc.).

BRAINSTORM

- List the problems that kids identified.
- Discuss different ways to tackle these problems. Record each idea. Seeing ideas together helps kids make imaginative connections that can often lead to even better solutions.

DEVELOP A PRELIMINARY DESIGN

- Make sure kids define what it means to succeed by having them set a goal and outline performance criteria.
- Have kids phrase their solutions as: "I will invent an x that does y."
- Encourage kids to talk to people who might use their invention.
- Have kids anticipate problems they'll need to solve as they build their projects.

BUILD

- Ask kids to list the materials they'll need.
- Have kids figure out substitutes for things that are unavailable or too expensive.

TEST, EVALUATE, AND REDESIGN

- Get kids to identify the kinds of tests that will help them perfect their invention.
- Have kids tell you how they will know when their invention has succeeded.
- Suggest that family, friends, and the ultimate users evaluate a kids invention.



MAKING A DIFFERENCE

Max, the winner of *Design Squad's* 2008 Trash to Treasure invention contest, has been inventing since he was six years old.



Max's "Home Dome" is a dwelling that's shaped like a Mongolian yurt. By stuffing packing peanuts into plastic grocery bags, Max solved two problems. He invented an effective shelter, and he found a new use for plastic bags and packing peanuts, items that cause litter and clog landfills.

SHARE SOLUTIONS

- Encourage kids to enter their invention in a contest.
- Have kids use the Internet to find out if a similar invention exists.

EXPAND SKILLS

Kids often dream up designs beyond what is possible given the materials, skills, and time available to them. Help them develop skills so they can tinker at home and turn their visions into reality by suggesting the following.

- Take discarded items apart to see how they work.
- Find an engineer or science teacher who can teach skills and provide expertise. For engineering societies that can help you locate a mentor, see Invention Resources (page 42).
- Attend weekend or summer programs to develop tinkering and building skills.

LOOK FOR OTHER PROGRAMS

Have your kids team up with like-minded peers by starting or joining an invention club.

- Start an invention club. (See page 7.)
- Future City (for middle school kids): futurecity.org
- InvenTeams (for high school kids): web.mit.edu/inventeams



Kids can apply the inventing skills they've learned to their own lives by identifying a need and then doing something about it by devising an original solution.

INVENT A BETTER WORLD



as built on TV
pbs.org/designsquad

Now that your invention skills are in top shape, it's time to apply them to your own life.

First, you have to identify a need. Then you have to invent a solution to do something about it!

You don't need to look far for things needing improvement. You can find them in your home, community, and school.

BRAINSTORM & DESIGN

- Choose one of the problems and brainstorm solutions.
- To better understand the problem, talk to people affected by it.

BUILD

- List the materials you'll need.
- Find someone to answer your questions.

TEST & REDESIGN

- Run tests to perfect your invention and to tell you when you've succeeded.
- Ask people who will be using your invention to try it.

SHARE YOUR SOLUTION

- Use the Internet to find out how others have solved the problem.
- Enter your invention in an invention contest.



Check out dozens of projects invented by kids at web.mit.edu/inventteams.



Watch DESIGN SQUAD on PBS or online at pbs.org/designsquad.

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APPENDIX

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- **THE DESIGN PROCESS
(TEAR-OUT POSTER)** p. 39
- **EDUCATION STANDARDS** p. 41
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- **SOURCES FOR MATERIALS** p. 43
- **RELATED PBS RESOURCES** p. 44

INVENT IT, BUILD IT

MAKE THE WORLD A BETTER PLACE



USE YOUR IMAGINATION



DESIGN THINGS THAT MATTER



BE CREATIVE



Get started inventing with



as built on TV.



Inspiring a New Generation of Inventors



PBS. pbs.org/designsquad

web.mit.edu/inventeams



Photos courtesy of Lemelson-MIT InvenTeams

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THE DESIGN PROCESS

Used by both inventors and engineers, the design process helps people think creatively about a problem and produce a successful result. The design process is a great way to tackle almost any task.



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web.mit.edu/inventeams

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EDUCATION STANDARDS

Challenge	Massachusetts Curriculum Frameworks Science and Technology/Engineering Standards										ITEA National Study of Technology Content Standards					National Science Education Standards																	
	Grades 3-5					Grades 6-8					Grades K-12					Gr. K-4					Grades 5-8												
Confetti Launcher Get-Moving Game Harmless Holder Speedy Shelter Convenient Carrier	Materials and Tools		1.1	1.2	1.3	2.1	2.2	2.3	2.4	2.1	1.1	1.2	1.1	1.2	1.3	1	2	3	6	8	9	10	11	12	18	20	Technology in Society	•	•	•	•	•	
	Engineering Design		2.1	2.2	2.3	2.4	2.1	2.2	2.3	2.4	2.1	1.1	1.2	1.1	1.2	1.3	1	2	3	6	8	9	10	11	12	18	20	Science and Technology	•	•	•	•	•
	Physical Science		1	4	5	2.1	2.2	2.3	2.4	2.1	1.1	1.2	1.1	1.2	1.3	1	2	3	6	8	9	10	11	12	18	20	Technological Design	•	•	•	•	•	
	Materials, Tools, and Machines		1.1	1.2	1.1	1.2	1.1	1.2	1.1	1.2	1.1	1.2	1.1	1.2	1.1	1.3	1	2	3	6	8	9	10	11	12	18	20	Motions and Forces	•	•	•	•	•
	Engineering Design		2.1	2.2	2.3	2.4	2.1	2.2	2.3	2.4	2.1	1.1	1.2	1.1	1.2	1.3	1	2	3	6	8	9	10	11	12	18	20	Technological Design	•	•	•	•	•
	Physical Science		1.1	1.2	1.3	2.1	2.2	2.3	2.4	2.1	1.1	1.2	1.1	1.2	1.3	1	2	3	6	8	9	10	11	12	18	20	Properties of Materials	•	•	•	•	•	
	Engineering Design		2.1	2.2	2.3	2.4	2.1	2.2	2.3	2.4	2.1	1.1	1.2	1.1	1.2	1.3	1	2	3	6	8	9	10	11	12	18	20	Science as Inquiry	•	•	•	•	•
	Materials, Tools, and Machines		1.1	1.2	1.3	2.1	2.2	2.3	2.4	2.1	1.1	1.2	1.1	1.2	1.3	1	2	3	6	8	9	10	11	12	18	20	Technology in Society	•	•	•	•	•	
	Engineering Design		2.1	2.2	2.3	2.4	2.1	2.2	2.3	2.4	2.1	1.1	1.2	1.1	1.2	1.3	1	2	3	6	8	9	10	11	12	18	20	Science and Technology	•	•	•	•	•
	Physical Science		1.1	1.2	1.3	2.1	2.2	2.3	2.4	2.1	1.1	1.2	1.1	1.2	1.3	1	2	3	6	8	9	10	11	12	18	20	Technological Design	•	•	•	•	•	

INVENTION RESOURCES

INVENT IT, BUILD IT PARTNERS

- **Design Squad**
pbs.org/designsquad
Brings engineering to life and engages kids with episodes, games, 35 hands-on challenges, and much more.
- **Lemelson-MIT InvenTeams**
web.mit.edu/inventeams
Offers a unique invention experience for high school students through its nationwide grants initiative, as well as information on invention and on awards to outstanding inventors offered by the Lemelson-MIT Program.

INVENTION PROJECTS

- **Discover Engineering**
discoverengineering.org
Find a host of projects, games, online activities, and videos about cool things engineers do and design.
- **Howtoons**
Howtoons.com
Uses a cartoon format to step kids through 15 fun build-it-yourself projects.
- **Inventors/Inventions**
edtech.kennesaw.edu/web/inventor.html
Offers lesson plans, activities, and research sites on invention for kids and educators.
- **The NASA SCience Files**
scifiles.larc.nasa.gov/text/kids/D_Lab/acts_invention.html
Includes invention experiments and simulations. Also get kids inventing with "The Case of the Wright Invention," a video and educator guide from the 2001-02 SciFiles season.
- **U.S. Patent and Trademark Office: Kids' Pages**
uspto.gov/go/kids
Offers an interactive kids' page with games, puzzles, and links.

INVENTION CONTESTS

- **The Christopher Columbus Awards**
christophercolumbusawards.com/enter.php
Challenges middle school students from around the country to identify a problem in their community and create an innovative solution.
- **eCYBERMISSION**
https://ecybermission.apgea.army.mil
Has kids in grades 6-9 invent science-, math-, and technology-based solutions to problems in their community and enter them in a free, Web-based competition.
- **ExploraVision**
exploravision.org
Encourages K-12 students to create and explore current technology and envision its future.
- **INVENT AMERICA!**
inventamerica.org
Provides K-8 students opportunities to learn critical and creative thinking skills through the process of inventing. Also hosts a national student invention contest.
- **National Museum of Education**
nmoe.org/competitions.htm
Offers a series of fun invention contests and a gallery of America's young inventors.
- **Tech Challenge**
techchallenge.thetech.org
Inspires kids' inner innovator by getting teams of 5-12 graders to develop creative solutions to real-world challenges in familiar settings.
- **TOYchallenge**
sallyridescience.com/toychallenge
Runs a national contest in which 5-8 graders create a new toy or game.

ABOUT INVENTION AND INVENTORS

- **Inventors and Inventions for K–12 Education**

falcon.jmu.edu/~ramseyil/inventors.htm

Lists Web sites about invention and inventors.

- **The Lemelson Center for the Study of Invention and Innovation**

invention.smithsonian.org/home

Hosts a wide variety of resources to encourage kids' inventive creativity and to enhance their appreciation for the role that invention and innovation plays in the history of the United States.

- **National Institute of Environmental Health Sciences Kids' Pages**

kids.niehs.nih.gov/quotes/qtinvent.htm

Offers inspirational quotes related to invention.

- **PBS's American Experience: Forgotten Inventors**

pbs.org/wgbh/amex/telephone/sfeature/index.html

Presents a diverse set of inventions from the past.

SOURCES FOR MATERIALS

Most of the required materials are easy to find at local stores. Often local merchants will offer educators discounted prices if you ask. If you are buying small quantities, try:

- **craft stores** for wooden spools and paper confetti;
- **office supply stores** for corrugated cardboard;
- **grocery stores** for aluminum baking tins, straws, and paper cups;
- **sporting goods and toy stores** for tennis balls and Ping-Pong balls;
- **party stores** for paper confetti;
- **school nurse's office** for crutches. (Also ask kids to bring crutches from home.); and
- **hardware or home-supply stores** for paint stirrers, bamboo plant stakes, duct tape, and large garbage bags.

Large quantities of these items are available online*. For example:

Corrugated cardboard	Ping-Pong balls	3-foot bamboo stakes	Wooden spools
papermart.com Item #261811	target.com Item#10731581	acehardware.com Item #048307210036	craftamerica.com item #SP138-50
uline.com Item #S-2437	ustoy.com Item #GS29	aubuchon.com Item #277616	woodcrafter.com Item #NS28

* Sources listed are examples of vendors who offer these items. Research the sources that best fit your needs.

RELATED PBS RESOURCES



Ages 3-6

Celebrate the curiosity and adventure of young children with simple science exploration.

peepandthebigwideworld.org



Ages 3-6

Discover science, engineering, and math in the world around us.

pbskids.org/curiousgeorge



Ages 8-11

Try ZOOM's fun science and engineering activities, featuring ideas sent in by real kids.

pbskidsgo.org/zoom



Ages 9-12

Investigate environmental issues and take action to protect the planet.

pbskidsgo.org/greens



Ages 6-10

Put problem-solving skills to the test to tackle science challenges inspired by ones seen on the show.

pbskidsgo.org/fetch



Ages 11 and up

Dig deep into science topics with classroom-ready resources from the most-watched science television series on PBS.

pbs.org/wgbh/nova



Ages 11 and up

Find out the latest research and meet intriguing personalities in science and technology.

pbs.org/wgbh/nova/sciencenow



Ages 14-18

Meet inspiring women engineers who make a real difference in the world. Find out if engineering might be your dream job.

engineeryourlife.org



Educators

Use this media-rich library of teaching resources to make concepts come alive in engaging and interactive ways.

teachersdomain.org

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MEET THE PARTNERS



as built on TV™

Design Squad gets kids and teens thinking like engineers and shows them that engineering is fun, creative, and something they can do themselves.

WATCH TV

Competition plus engineering plus two teams of kids equals fun! See it on PBS.

DO HANDS-ON CHALLENGES

Design Squad challenges bring engineering to life. Download all 35 from pbs.org/designsquad/parentseducators.

VISIT THE WEB SITE

Get episodes, games, cast information, details about the show, educational resources, and much more. Visit pbs.org/designsquad.

HOST EVENTS

Take *Design Squad* to a museum, library, or mall and spark kids' interest in engineering with a lively, fun-filled event. Get the Event Guide at pbs.org/designsquad/parentseducators.



LEMELSON-MIT PROGRAM

celebrating invention and innovation

The Lemelson-MIT Program recognizes outstanding inventors, encourages sustainable new solutions to real-world problems, and enables and inspires young people to pursue creative lives and careers through invention. Find out more at web.mit.edu/invent.



InvenTeams is a national initiative of the Lemelson-MIT Program designed to excite high school students about invention, empower them to problem solve, and encourage an inventive culture in schools and communities. Find out more at web.mit.edu/inventeams.

- Supports the establishment of invention clubs in schools.
- Offers teams of high school students and mentors grants of up to \$10,000 to invent a solution to a problem they've identified.
- Runs teacher trainings about invention and inventing.
- Provides design challenges and other educational resources.

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