Smithsonian

Facilitator Manual

developed exclusively for American Spaces

Smithsonian
National Museum of American History
Lemelson Center for the Study of Invention and Innovation

Facilitator Manual Table of Contents

About Spark!Lab

Spark!Lab, the flagship educational initiative of the Lemelson Center for the Study of Invention and Innovation, is a hands-on invention workspace where visitors can learn about and engage in the history and process of invention. The original Spark!Lab opened at the Smithsonian's National Museum of American History (NMAH) in November 2008, and before closing for renovation in 2012, served more than 600,000 people. Spark!Lab received high praise for its interactive and hands-on nature and became a primary destination within the museum. On July 1, 2015, the new Draper Spark!Lab opened in the renovated West wing on the first floor of NMAH.

Spark!Lab has three main educational messages:

- Invention is a process.
- Everyone is inventive.
- Invention and innovation have been—and continue to be—an important part of the American Experience.

Spark!Lab offers different types of activities to illustrate the invention process. **Activities are designed to appeal to varied learning styles, ages, and abilities; allow participants to practice 21st century skills like collaboration, critical thinking, and problem solving; and incorporate a variety of disciplines including history, science, engineering, and art.** Activities are organized around the *process of invention*, with key steps in the process aligned with related "it" phrases:

Have a great idea for an invention.

Investigate inventions, ideas, and designs that already exist.

Draw pictures and diagrams of your invention to figure out how it might work.

Build a prototype or model of your idea.

Test your invention.

Keep improving your idea.

Talk about your invention.

Spark!Lab activities are designed to be very flexible. Though originally intended for children and families, activities are easily adapted for teenagers and adults. They can be used individually or in combination with one another, and can be deployed successfully in informal settings or as part of structured programs or events.

Spark!Lab activities are designed to be attended by a facilitator. **Unlike a traditional classroom teacher, a facilitator does not instruct, lecture, or lead participants through an activity step-by-step.** Instead, he/she provides minimal assistance, employing inquiry-based learning (questioning) techniques to help participants work through challenges, identify design solutions, and create their own unique inventions.

In addition to the Draper Spark!Lab in Washington, DC, the Lemelson Center has established the Spark!Lab National Network, partnering with institutions across the United States to open Spark!Labs in other communities. The first satellite site opened in 2011 at the Nevada Discovery Museum in Reno. In 2014, additional labs opened in Kansas City, MO and Pittsfield, MA, and in 2015, Anchorage, AK. The Lemelson Center is currently working with additional partners to open labs in 2016 and beyond.

In addition to its domestic sites, the Lemelson Center has hosted temporary Spark!Labs in Kyiv, Ukraine and Gurgaon, India.

The Role of the Facilitator

While Spark!Lab activities are designed to be participant-directed, they work best when facilitated. Facilitators not only help ensure that all materials and activity components stay intact, but also deepen the participant experience. A 2010 evaluation conducted in Spark!Lab in Washington, DC found that people who interacted with a staff member or volunteer were twice as likely to rate their experience as outstanding than those who had no interaction.

The facilitator does not need prior engineering, building, or design experience to facilitate a successful and interesting program. Ideas and strategies included in this manual offer a framework for hosting a successful Spark!Lab program and facilitating an effective, fun, and meaningful educational experience.

Facilitators can model or show participants how to use the activities and can discourage inappropriate or wasteful usage of the materials. They can also use inquiry learning (questioning) techniques to invite participants to interact with the materials or to try a different approach to an activity. Effective inquiry can lead to meaningful thinking, observation, actions, experimentation, innovation, reflection, hypothesizing, testing, problem solving, exploring, and play. Inquiry provides an active learning experience that leads participants to direct their own investigation and find their own answers, which usually leads them to more questions!

Facilitators can use different types of questions to engage participants in inquiry learning:

- Factual questions – These questions have a correct answer.
  Examples: Will the light or the heavy object balance your mobile? Who worked with you on your invention?
- Interpretive questions – These questions have more than one answer, but answers are supported by evidence. Participants' agendas and prior knowledge influence their answers, so different people often have different answers.
  Examples: How do you think these materials are different? Was the invention process difficult or easy?

- Evaluative questions – These questions are intended to generate an opinion, belief, or point of view, so they have no wrong answers. Like interpretive questions, answers to evaluative queries are influenced by the participants' agendas, prior knowledge, and experience.
  Examples: Why did you choose those materials to create your invention? What would happen if...?

In Spark!Lab, facilitators typically focus on Interpretive and Evaluative questions. These questions are open-ended, offer opportunity for participants to express their own ideas and interpretations, and generally lead to longer, more meaningful interactions.

Facilitation questions and ideas specific to each activity are included with each individual activity training guide.

Basic Facilitation Tips

Unlike a traditional classroom teacher, a facilitator does not instruct, lecture, or lead participants through an activity step-by-step. Instead, he/she provides minimal assistance, employing inquiry-based learning (questioning) techniques to help participants work through challenges, identify design solutions, and create their own unique inventions.

Here are a few basic tips and strategies for welcoming participants to Spark!Lab, introducing and engaging them in an activity, and facilitating their inventing and learning experience.

Greet participants

Say hello, make eye contact, and smile. Simply looking like you are available and friendly will make participants feel welcome. These suggestions are useful whether you're hosting a drop-in program or a more formal one. Because Spark!Lab activities are often different from what participants have experienced in the past, they can be unsure about where to start or what to do. You can provide a brief description of the activity available, and let participants know they can explore the activity and materials at their own pace. Eventually, you might recruit volunteers to serve as "Spark!Lab Ambassadors" in your American Space.

Let participants do the activity

As much as possible, let participants do the activities on their own. You can offer basic guidance, but the activity should not be led step-by-step (e.g. first you have to do this, then do that). Remember—you are facilitating and encouraging the process of invention, not teaching or explaining.

Share what you know

Use clear, simple language. Focus on one main idea—don't feel that you need to tell participants everything at once! Keep the information basic to start, and be willing to expand on an idea for interested learners.

Use examples from everyday life

Familiar examples can help explain abstract concepts. Be aware of participants' abilities, keeping in mind that participants may not all have the same skills, vocabulary or interests. Think of things in your local community that might relate to different activities, or bring in a current event to illustrate a point or concept. In addition to clarifying the concept, this also helps send the message that invention and innovation are all around us.

Ask questions

Help participants observe and think about the activity. Try to use questions that have more than one answer:

- What are you inventing?
- Why do you think that happened?
- What surprised you about what you saw (or did)?
- Does this remind you of anything you have seen before?
- What do you think will happen if you do this or try that?

If a participant seems frustrated or is having a hard time making an activity work the way he/she wants, ask questions or offer prompts to guide the participant in fine-tuning his/her project:

- How do you want this to work? What do you want to happen?
- What is happening instead?
- How do you think we might change this so that it works better? [Using "we" helps participants feel that you are in it together and that they can help in solving the problem.]
- Have you tried _____? [Suggestions might include making it taller or shorter, adjusting a piece or component, or even starting over and trying again.]

Be a good listener

Be interested in what participants tell you, and let their curiosity and responses drive your conversation forward. Take cues from them about what their interests, abilities, and skill levels are and then gear your conversation toward those things. Also suggest other things in your community that might connect with what they are doing in Spark!Lab. As much as possible, you want to help participants make connections between their experiences in Spark!Lab and the wider world.

Offer positive, encouraging, and <u>specific</u> responses

If you ask a question and a participant gives an incorrect answer, he/she probably hasn't quite grasped the concept. If this happens, you might say "That's a good guess" or "Very close, does anyone else have something to add?" Try to avoid saying "no" or "wrong" in response to an observation or explanation. Sometimes following up a wrong answer with "That's interesting. Can you tell me more about why you think that?" can provide insight into a respondent's thought process. Even if the answer is wrong, often participants are on the right track with their thinking.

Validate what the participant has said and then steer him/her toward the right answer by offering a little more information or asking a more specific question.

If a participant shows you his/her invention, try to give as specific a response as possible. Instead of saying, “Good job!” or “That’s cool!,” find something unique about the project on which to comment. For example, “I really like the way you arranged the items on your mobile and coordinated the colors” is more specific and more meaningful to the participant than “I like your mobile.”

Share accurate information

If you are not sure about something, it is okay to say, “I don’t know.” You can refer participants to some of the Smithsonian resources included in the activity training guides. You may also want to have a “cheat sheet” of good websites so that you can encourage participants to search for solutions or answers to their questions. You can also encourage participants to find answers on their own once they leave a Spark!Lab program. You might say, “That’s a great question, but I don’t know. Where do you think you might look for the answer?” and collectively brainstorm a list of possible sources (books, articles, websites, etc.).

Remain positive throughout the interaction

Remember that nonverbal communication is important. Try to maintain an inviting face and open body language. Smile frequently. Avoid looking at your phone or watch. Also remember to take cues from the participant’s body language. Not everyone will want to have a one-on-one experience with you. Greet everyone and watch out for signs that someone might need help, but if someone has given hints that he/she does not want a lot of guidance, intervene only when it looks like they are frustrated, confused, or (in rare cases) using the materials inappropriately.

HAVE FUN!

A positive experience will lead to meaningful engagement and learning for participants. Ideally, you can host a series of Spark!Lab activities and encourage participants to return to your American Space again.

Using the Language of Invention

When facilitating a Spark!Lab activity in your American Space, it is important to use the language of invention. Using specific words, phrases, and questions helps reinforce the message that "Everyone is inventive" and helps participants to see that they are using the same skills and abilities that "real" inventors use in their work.

The language can also be used to inspire someone. For example, if someone is copying another invention, a facilitator can use that opportunity to say something like, "Inventors often use other people's creations as their starting point. How can you make your invention different from your friend's?"

Using the language of invention also can help heighten participants' awareness to invention generally, and help them see that invention really is all around us.

Some phrases and questions that facilitators can use include:

- What are you inventing?
- You're doing just what an inventor does!
- Inventors often have trouble at first, too, but they keep trying until they find a solution. You can do it!
- That's really inventive!
- What is your invention designed to do?

While facilitators are encouraged to use this language liberally and to find creative ways to reinforce the "Everyone is inventive" message, it is also important to use these words and phrases genuinely and appropriately. Use them when participants are actually creating something of their own design or are really working through the invention process. For example, if someone is sketching, that's a great opportunity to point out that they are working through an important part of the invention process and doing what many inventors do.

In the Mobile Masterpieces activity, however, participants create their own mobiles. The mobile as an art form itself has already been invented, so facilitators should probably not ask a visitor about his/her "invention," but rather point out the innovative way in which the participant selects, arranges, and balances the items on his/her mobile.

Activity Descriptions

Flying Machines
Participants use simple materials to engineer their own flying inventions! The instructional sign encourages participants to create things that fly like a rocket, bird, airplane, or parachute. Participants are encouraged to test and tweak their designs to improve aerodynamics, distance flown, and accuracy.

Grab Bag Inventing
Grab Bag Inventing allows participants to try playful inventing and helps them recognize their own creative abilities. Participants are given a challenge or problem to solve and simple materials with which to solve it. There is no one "right" solution to the challenge, and participants are encouraged to think as creatively as possible! Participants can work alone or in groups, and this activity could work well for a structured workshop or program. Grab Bag Inventing challenges can be developed around an almost endless range of topics and themes and is appropriate for audiences of all ages.

Invent-A-Vehicle
Participants work together to build a vehicle to solve a specific problem. Vehicles are constructed from reusable materials and components on a scale that encourages collaboration, imagination, and functional testing. The larger the variety of materials available, the more creative innovation is possible! This activity works well with individuals as well as groups.

Mobile Masterpieces
Artists take properties from science and incorporate them into their work. The mobile is a great example of science merging with art, and a great way to express inventive thought and creativity. With the use of scales and balance, the mobile takes on great beauty. This activity

allows participants to explore the scientific principles of balance and scale, and create their own inventive mobiles.

Shaping Space
Structures are built and engineered according to their intended purpose. Participants use imagination, problem-solving, and the construction materials provided to find inventive ways to shape spaces that meet architectural challenges.

Each activity training guide includes facilitator tips, materials needed, recommended time, and other relevant information for leading a Spark!Lab program.

The Process of Invention

One of Spark!Lab's key messages is "Invention is a process." Each of the activities incorporates some of the steps listed below, and allows participants in your American Space to engage in the process through hands-on exploration. While the process of invention is not always linear, inventors usually engage in the following activities in some order to take their idea from concept to finished product:

Have a great idea for an invention.

Investigate inventions and ideas of the past.

Draw pictures and diagrams to figure out how your invention might work.

Build a prototype or model of your idea.

Test your invention!

Keep improving your idea.

Talk about your invention.

Educational Framework

One of the primary goals of Spark!Lab is to help participants understand that invention is a process (rather than a single "Eureka!" moment) and to provide opportunities to engage in that process. Understanding the process and building skills around experimentation, risk taking, critical thinking, and problem solving can empower participants to apply the approach in a variety of other situations and can help to create a strong civic society.

The steps in the invention process are aligned with the 21st Century Skills Framework (http://www.p21.org/our-work/p21-framework). This U.S.-based educational model describes the skills, knowledge, and expertise students must master to succeed in work and life in the 21st century. They are a blend of content knowledge, specific skills, and expertise. Spark!Lab activities help participants practice and hone the following 21st Century Skills while engaging in the invention process:

LEARNING AND INNOVATION SKILLS

Creativity and Innovation

- Think creatively
    - Create new and worthwhile ideas (both incremental and radical concepts)
    - Elaborate, refine, analyze and evaluate their own ideas in order to improve and maximize creative efforts
- Work creatively with others (if working with a partner or group)
    - Develop, implement and communicate new ideas to others effectively
    - Be open and responsive to new and diverse perspectives; incorporate group input and feedback into the work
    - Demonstrate originality and inventiveness in work and understand the real world limits to adopting new ideas
    - View failure as an opportunity to learn
- Implement innovations

- Act on creative ideas

Critical Thinking and Problem Solving

- Reason effectively
  - Use various types of reasoning (inductive, deductive, etc.) as appropriate to the situation
- Use systems thinking
  - Analyze how parts of a whole interact with each other to produce overall outcomes
- Make judgments and decisions
  - Interpret information and draw conclusions based on the best analysis
  - Reflect critically on learning experiences and processes
- Solve problems
  - Solve different kinds of non-familiar problems in both conventional and innovative ways

Communication and Collaboration (if working with a partner or group)

- Communicate clearly
  - Communicate effectively in diverse environments
- Collaborate with others
  - Demonstrate ability to work effectively and respectfully with diverse teams
  - Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal
  - Assume shared responsibility for collaborative work, and value the individual contributions made by each team member

LIFE AND CAREER SKILLS

Flexibility and Adaptability

- Be flexible
  - Incorporate feedback effectively
  - Deal positively with praise, setbacks and criticism

Initiative and Self-Direction (if working alone)

- Manage goals and time
  - Set goals with tangible success criteria
- Work independently
  - Monitor, define, prioritize and complete tasks without direct oversight
- Be self-directed learners

- Go beyond basic mastery of skills to explore and expand one's own learning and opportunities to gain expertise

In addition to the specific skills, Spark!Lab activities incorporate the following disciplines:

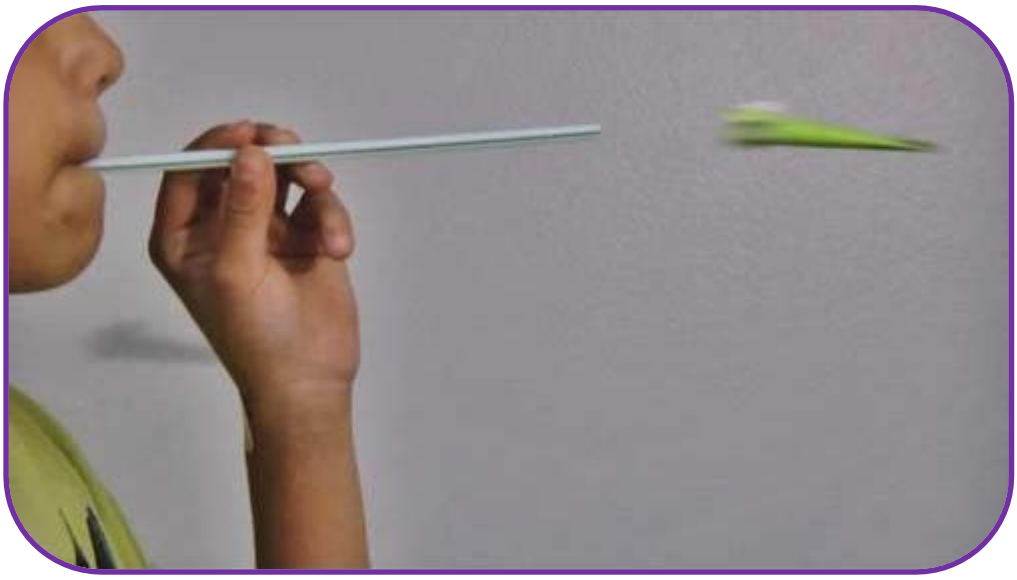
- Reading
- Arts
- Mathematics
- Science
- Geography
- History
- Engineering

Spark!Lab activities also address other U.S. learning standards:

Common Core Standards	21st Century Skills	Next Generation Science Standards	STEAM
Speaking and Listening Skills • Comprehension and Collaboration • Presentation of Knowledge and Ideas	**Learning and Innovation Skills** • Creativity and Innovation • Critical Thinking and Problem Solving • Communication and Collaboration **Life and Career Skills** • Initiative and Self-Direction	**Engineering Design** • Define • Develop Solutions • Optimize	**Science** • Conduct scientific inquiry through the Spark!Lab process of invention **Engineering** • Solve a problem • Design an invention • Build a prototype **Arts** • Imagine and sketch an invention • Create a 3-D prototype **Math** • Measure and create a scale model of the invention • Analyze data to refine an invention

Lastly, engaging in Spark!Lab activities is also a great way for participants to **practice English** and for facilitators to promote English language learning.

Flying Machines



A participant fires his Flying Machine

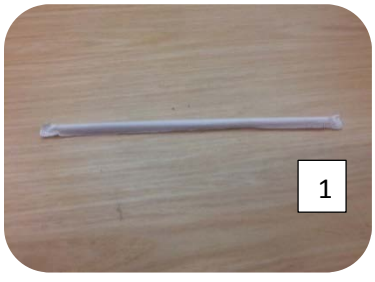
Flying Machines Overview

The Big Idea

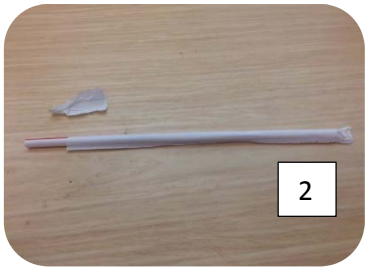
Participants use simple materials to engineer their own flying inventions! The instructional sign (described below) encourages participants to create things that fly like a rocket, bird, airplane, or parachute. Participants are encouraged to test and tweak their designs to improve aerodynamics, distance flown, and accuracy.

Facilitation Level: Moderate to High

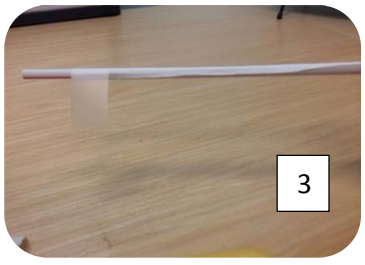
- Many participants will need help in preparing their straw for the activity. As the instructions indicate, “Tear off about an inch of the straw wrapper. Wrap a piece of tape around the torn off end. Be sure that the tape is on the wrapper only. Do not tape the wrapper to the straw.” See photos for more guidance:



Paper wrapped straw



Straw with about 1" of wrapper torn off



Straw with tape wrapped around end of paper

- The tape helps strengthen the wrapper and makes it easier to put the wrapper back onto the straw multiple times for testing.

- As the facilitator, you can lead a demonstration for an individual or a group, and then encourage them to prepare their own straws. Try to avoid doing it for participants; part of the activity is working through the challenge of unwrapping and taping the straw. Once you have shown one participant or group the procedure, they will often teach others.

- You will also need to manage the supplies and keep the activity area safe for participants.

- You also may need to assist participants in working through trouble spots or frustrations if their Flying Machines do not work exactly as they had envisioned.

- If you are using this as a group activity, you will need to structure the activity, assign challenges, and lead debriefs. (Please see the **Working with Groups** section below for more specific details.)

- You do not need any prior engineering, building, or design experience to facilitate this activity effectively. You should, however, try the activity out yourself before facilitating it with a group to ensure that you have a comprehensive understanding of the activity and how the materials work.

Average Activity Length

- 15-30 minutes for individuals
- 20-40 minutes for structured groups

Activity Supplies and Materials*

- Straws wrapped in paper
- Tape
- Construction paper
- Paper clips
- Yarn or string
- Coffee filters
- Scissors
- Scraps or leftovers from other activities
- Activity Instruction Sign** [printed to be at least 11” x 14” in size]:
    - Invent a Flying Machine to…
        - Launch like a rocket

- Fly like an airplane
- Fall slowly like a parachute
- Flutter like a butterfly
- Glide like a bird

Tear off about an inch of the straw wrapper.
Wrap a piece of tape around the torn off end. Be sure that the tape is on the wrapper only. Do not tape the wrapper to the straw.
Use the materials provided to add on to the straw wrapper. This will be your flying machine.
Test your creation by blowing into the straw.
Keep tweaking and testing your invention until you have the flying machine of your dreams!

*A note about Activity Supplies and Materials

The wrapped straws are critical for the success of this activity. The other supplies and materials listed above, however, are simply suggestions. Almost any type of craft, office, or household supply can be used with Flying Machines. Recyclable materials can also be incorporated. The important thing will be to provide materials that can be easily used by participants of all ages, and that allow everyone to have success in creating flying objects.

You will also want to have some way to organize the different supplies and materials. Simple plastic containers work well. It is best to separate core supplies like straws, scissors, and tape from the add-on items. You will also want to have a trash can nearby to make clean-up for both you and your participants easy.

**An Activity Instruction Sign can be found at the end of this training guide.

Outcomes

By participating in this activity, individuals will:

1) engage in the invention process through a hands-on design and building activity
2) set a goal and use problem-solving and critical-thinking skills to reach it
3) understand that failure—and resiliency—are often part of the invention process
4) exercise inventive thinking skills
5) begin to identify themselves as inventive thinkers and problem-solvers

Related Invention Process Steps

Have a great idea for an invention.

Investigate inventions, ideas, and designs that already exist.

Build a prototype or model of your idea.

Test your invention.

Keep improving your idea.

Talk about your invention. (This applies mostly when you are working with groups and include debriefs in the activity.)

Flying Machines Implementation

Facilitation Ideas

- This activity works best when there is a facilitator available to get participants started and to encourage them to tweak their designs after initial testing. A facilitator also can help keep the activity orderly and neat and supplies stocked.

- There is not a “right” or “wrong” way to approach this activity. Participants should be encouraged to be as creative as possible. Their creations do not have to fly exactly like a rocket, plane or bird. The most important part about this activity is the testing and tweaking process. We want participants to understand the value of testing, and how invention is often an iterative process.

- Participants almost always want to jump right in and start adding materials to their straw wrapper. A facilitator can suggest, however, that participants test the straw wrapper before making any modifications. Ask participants to observe what they see on that initial test, and to think about how they can modify the wrapper to make it fly the way they want it to.

- Because participants often have to make several attempts before they get something to fly the way they want it to, they can get frustrated. Some questions to ask participants that can help with frustration and keep them focused include:
    - What kind of flying machine are you inventing?
    - How does a [rocket, plane, parachute, butterfly, bird] fly? What makes it different from other things that fly?
    - What happened when you tested your invention? What did you like about how it flew, and what would you like to improve?

- Do you think your flying machine is too heavy/too light? What could you do to your design to change the weight?
- What materials have you chosen? Are there other materials that might make it fly differently?
- Have you run into any challenges in creating your flying machine? How did you overcome them?

- You may occasionally find someone taking an invention away from another participant to "do it right" or "fix it." If that happens, re-involve the excluded participant by starting something new or giving him/her a new flying challenge to work on.

Working with Groups

- Flying Machines can be used with structured groups, though you will probably want to limit the number of people working on this activity at one time to 6-8. If the group is larger, you can split into smaller groups. Assign one group to Flying Machines, and other groups to other activities. If there is time, groups can rotate through each of the activities.

- It is best if you pool all of the supplies together rather than split up the supplies for each group. Part of this activity—with all participants, but especially with groups—is providing them opportunities to collaborate across groups, to trade or barter supplies, and to work with limited resources. This models how real inventors work.

- Group members will work individually during this activity.

- There are two ways to structure the activity for groups:
  - First, you can give all participants the same challenge (e.g. invent something that flies like a bird). At the end, debrief the activity and have each person explain how he/she solved the challenge. It is very likely that the designs will all look different, which can lead to a rich discussion about how there are many ways to solve a single problem.
  - A second option is to give everyone in the group a different challenge. Again, you will want to debrief at the end and have each person present his/her design.
  - During the debrief period, ask the groups what was challenging, if their designs changed during the process, and how they overcame obstacles. Reinforce that the work they did during this fun activity is what real inventors do!

- Many of the strategies listed in the **Facilitation Ideas** section above can also be used when working with groups.

Other Tips

- This activity is very flexible so it is ok to change the add-on materials periodically. Other than basic supplies like straws, scissors, tape, and yarn or string, there is nothing that is specifically required for this activity. Changing materials (even just a few selections) also keeps the activity fresh for repeat participants. This activity provides a great opportunity to use up scraps or leftovers from other activities.

- When using Flying Machines, it is best not to have another activity that uses consumable supplies out at the same time. Maintenance and clean-up can be challenging when there are multiple activities to monitor and replenish.

Safety and Maintenance

- The biggest challenge with this activity will be to keep the supplies orderly. In making their flying machines, participants will often use a variety of supplies and leave scraps and trash behind. Encourage them to recycle larger scraps and to throw away trash. Facilitators should periodically clean up the area and reset the supplies so the activity does not get too messy.

- You will need to check the material supply frequently to ensure that there is always a variety of things out with which participants can create. But you may want to experiment with the amount of materials out at any one time. You may discover that the activity works better when you have out only a few of each different item. You will want to find the right balance so that there are enough supplies for everyone who wants to enjoy the activity, but there aren't too many things so that it is unmanageable for the staff and volunteers. Also, scarcity of resources and supplies can often lead to more creativity!

Smithsonian Connections[AL1]

- Resources from the Lemelson Center for the Study of Invention and Innovation
    - Podcast: Space Innovation – http://invention.si.edu/podcast-howard-mccurdy-examines-government-influence-space-innovation
    - Podcast: Civil War Technologies – http://invention.si.edu/podcast-civil-war-communications-technologies-part-2-2
    - Podcast: Human-powered Flight – http://invention.si.edu/podcast-paul-maccreadys-inventions-do-more-less

- Resources from the National Air and Space Museum (NASM)
    - Featured Inventors: The Wright Brothers - http://airandspace.si.edu/exhibitions/wright-brothers/online/
    - Exhibitions: NASM Online Exhibitions – http://airandspace.si.edu/exhibitions/online/
    - Collections: Search NASM Collections – http://airandspace.si.edu/collections/objects.cfm

- Resources from the National Museum of Natural History (NMNH)
    - Collections: Birds at NMNH – http://vertebrates.si.edu/birds/
    - Collections: Butterflies at NMNH - http://entomology.si.edu/Collections_Leps.html

About Spark!Lab

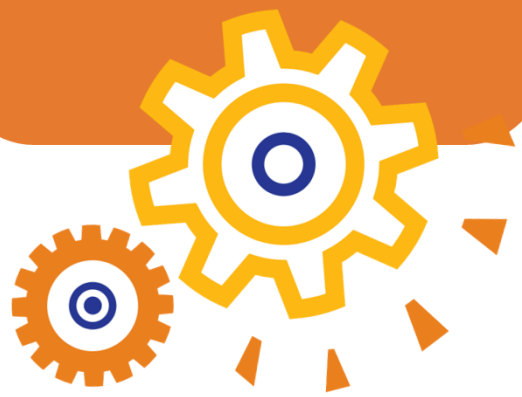
Spark!Lab is the flagship educational initiative of the Smithsonian's Lemelson Center for the Study of Invention and Innovation. It is a hands-on invention workspace where Participants can learn about and engage in the history and process of invention. Participants to Spark!Lab can participate in a variety of activities that illustrate the invention process and appeal to varied learning styles, ages, and abilities. Activities also allow Participants to practice 21st century skills, like collaboration, problem-solving, and critical thinking, and incorporate a variety of disciplines including history, science, engineering, and art. To learn more, visit http://invention.si.edu/try/sparklab.

Flying Machines Images for Inspiration

Flying Machines Activity Instruction Sign

Invent a Flying Machine to…

- Launch like a rocket
- Fly like an airplane
- Fall slowly like a parachute
- Flutter like a butterfly
- Glide like a bird



1) Tear off about an inch of the straw wrapper.

2) Wrap a piece of tape around the torn off end. Be sure that the tape is on the wrapper only. Do not tape the wrapper to the straw.

3) Use the materials provided to add on to straw wrapper. This will be your flying machine.

4) Test your creation by blowing into the straw.

5) Keep tweaking and testing your invention until you have the flying machine of your dreams!

Grab Bag Inventing

A participant shows off his Grab Bag Inventing creation

Grab Bag Inventing Overview

The Big Idea

Grab Bag Inventing allows participants to try playful inventing and helps them recognize their own creative abilities. Participants are given a challenge or problem to solve and simple materials with which to solve it. There is no one "right" solution to the challenge, and participants are encouraged to think as creatively as possible! Participants can work alone or in groups, and this activity can work well for a structured workshop or program. Grab Bag Inventing is appropriate for audiences of all ages, and challenges can be developed around an almost endless range of topics and themes.

Facilitation Level: Moderate

- As the facilitator, you will need to manage the supplies and keep the activity area safe for participants.

- You also may need to assist participants in working through trouble spots or frustrations if their inventions do not turn out exactly as they had envisioned.

- If you are using this as a group activity, you will need to structure the activity, assign challenges, and lead debriefs. (Please see the **Working with Groups** section below for more specific details.)

- You do not need any prior engineering, building, or design experience to facilitate this activity effectively. You should, however, try the activity out yourself before facilitating it with a group to ensure that you have a comprehensive understanding of the activity and how the materials work.

Average Activity Length

- 15-30 minutes for individuals
- 20-40 minutes for structured groups

Activity Supplies and Materials*

Almost any type of craft, office, or household supply can be used with Grab Bag Inventing. Recyclable materials and simple (and safe) hardware can also be incorporated. Here is a suggested—but by no means exclusive or exhaustive—list of materials:

- Craft sticks
- Paper cups and plates
- Paper clips
- Pipe cleaners
- Clothes pins
- Balloons
- Fabric or felt swatches
- String, yarn or ribbon
- Washers, nuts, and other hardware
- Sponges (cut into smaller pieces)
- Recyclable materials, like egg cartons, yogurt cups, and paper towel rolls
- Construction paper
- Scissors
- Tape
- Glue sticks
- Markers
- Crayons
- Challenge Cards with the following challenges** [each printed to be at least 8 ½" x 11" in size]:
    - You live in an area that has both a rainy season and a dry season. Construct a water storage system that allows you to collect water in the rainy season so that you can use it during the dry season.
    - Your farm is several miles from the nearest market. Build a vehicle on which you can transport your crops from farm to market safely and efficiently.
    - Your best friend uses a wheelchair to get around. Invent a carrier he or she can use to easily carry things to your house for a sleepover.
    - Invent something that can warn you a tornado is coming, even if the electricity goes out.
    - You have to walk from classroom to classroom during the school day. Since you are moving all the time, it is hard to keep track of all of your school supplies. Invent something to carry your supplies in.
    - *Feel free to make up your own and/or have participants submit suggestions. This can be a great way to apply problem solving to a locally relevant issue.*

- Optional items
    - Sketching materials (paper, pencils, whiteboard, markers)

*A note about Activity Supplies and Materials

Almost any type of craft, office, or household supply can be used with Grab Bag Inventing. Recyclable materials can also be incorporated. The important thing will be to provide materials that can be easily used by participants of all ages, and that allow everyone to have success in creating inventions based on the Challenge Cards.

You will also want to have some way to organize the different supplies and materials. Simple plastic containers work well. It is best to separate core supplies like scissors and tape from the other items. You will also want to have a trash can nearby to make clean-up for both you and your participants easy.

**Challenge Cards can be found at the end of this training guide.

Outcomes

By participating in this activity, individuals will:

1) exercise inventive thinking skills
2) set a goal and use problem-solving and critical-thinking skills to reach it
3) begin to identify themselves as inventive thinkers and problem-solvers

Related Invention Process Steps

Have a great idea for an invention.

Investigate inventions, ideas, and designs that already exist.

(Optional step) Draw pictures and diagrams of your invention to figure out how it might work.

Build a prototype or model of your idea.

Keep improving your idea.

Talk about your invention. (This applies mostly when you are working with groups and include debriefs in the activity.)

Grab Bag Inventing Implementation

Facilitation Ideas

- You will probably want to select one or two challenges to have out at any given time. Offering more than two may be overwhelming for participants, and will also make it harder to have appropriate materials for the challenges. You may also decide to create more of a challenge for older audiences by giving them a certain amount of time to create their invention.

- There is not a "right" or "wrong" way to approach this activity. Participants should be encouraged to be as creative as possible. Their creations do not have to work as true inventions; the goal is to create a three-dimensional representation of their idea. This offers a great opportunity for participants to explore different tools and materials, learn about the benefits (or drawbacks) of working with different items, and practice their English.

- Participants will sometimes complain that they do not have the "right" tool or material available, and that they cannot finish their invention without it. You can remind them that, when creating prototypes, most inventors use whatever they have on and in their workshops. Just like Spark!Lab participants, inventors do not have every tool and material in the world available to them! This encourages inventors to be creative and to look at familiar materials in new ways.

- Some questions to ask participants while they are working with this activity include:
    - What challenge or problem are you trying to solve?
    - How will your invention help to solve that problem?
    - How is it different from other inventions?
    - Is it a brand new idea or an improvement on something that exists already?
    - What materials have you chosen to use in your prototype?

    - Who will use your invention? How might you market it?
    - Have you run into any challenges in creating your invention? How did you overcome them?

- Some participants will begin to create with no specific end goal. This is ok; they are learning how the tools and materials function and what their strength and limitations are, all while being creative. Sometimes asking questions like those above will encourage participants to consider their work more thoughtfully and will help direct their ideas.

- If a participant is frustrated with his/her invention or feels he/she is doing it "wrong," offer assurance that there is no right or wrong way to create. Ask what is being attempted and offer an idea or two to get the participant back on track. (What happens if you try this? What if you added something here?) You can also suggest that a participant try sketching their idea; sometimes sketching can help work through the trouble spot.

- You may occasionally find someone taking an invention away from another participant to "do it right" or "fix it." If that happens, re-involve the excluded participant by starting something new or giving him/her a new challenge to solve.

Working with Groups

- Grab Bag Inventing can be used very effectively with structured groups.

- You will want to split larger groups into several smaller groups of 3-6 people each. Each small group will work together to create a single invention. The total number of people who can participate will depend on the amount of supplies you have. You will want to be sure that all groups can successfully accomplish the activity with the materials available.

- It is best if you pool all of the supplies together rather than split up the supplies for each group. Part of this activity—with all participants, but especially with groups—is providing them opportunities to collaborate across groups, to trade or barter supplies, and to work with limited resources. This models how real inventors work.

- There are several ways to structure the activity:
    - You can specify that the groups brainstorm ideas and sketch before they can begin building. This is recommended only if the group has at least 20 minutes to spend on the entire activity.
    - You can select a Challenge Card and give all of the groups the same challenge. At the end, debrief the activity and have each group explain how it solved the challenge. It is

very likely that the designs will all look different, which can lead to a rich discussion about how there are many ways to solve a single problem.
    - Another option is to give each group a different Challenge Card. Again, you will want to debrief at the end and have each group present its design. This is a good opportunity to remind groups that inventors often have to pitch their ideas to others.
    - During the debrief period, ask the groups what was challenging, if their design changed during the process, and how they overcame obstacles. Reinforce that the work they did during this fun activity is what real inventors do!

- Many of the strategies listed in the **Facilitation Ideas** section above can also be used when working with groups.

Other Tips

- This activity is very flexible so it is ok to change the materials periodically. Other than basic supplies like scissors and tape, there is nothing that is specifically required for this activity. Changing materials (even just a few selections) also keeps the activity fresh for repeat participants. Of course, you will want to choose materials that lend themselves to the specific challenge(s). For example, if participants are challenged to create a vehicle, there should be some sort of material that could be used to create wheels. This could be bottle caps, old CDs, or even cardboard that could be cut into circles.

- Additional Grab Bag Inventing challenges can be developed around almost any theme or idea, so this is a great activity to tie into community events or contemporary issues. When developing new challenges, it is important that they are open-ended and allow for many possible solutions. For example, you would want to ask participants to invent a “vehicle” rather than a “car.” A vehicle can take many forms, whereas a car is a very specific thing. Similarly, you would challenge participants to create a “carrier” instead of a “backpack.”

- When using Grab Bag Inventing, it is best not to have another activity that uses consumable supplies out at the same time. Maintenance and clean-up can be challenging when there are multiple activities to monitor and replenish.

Safety and Maintenance

- The biggest challenge with this activity will be to keep the supplies orderly. In making their inventions, participants will often use a variety of supplies and leave scraps and trash behind. Encourage them to recycle larger scraps and to throw away trash. Facilitators should periodically clean up the area and reset the supplies so the activity does not get too messy.

- You will need to check the material supply frequently to ensure that there is always a variety of things out with which participants can create. (Note: this would be less crucial for facilitators hosting one specific event rather than leaving the activity out and available at all times.) But you may want to experiment with the amount of materials out at any one time. You may discover that the activity works better when you have out only a few of each different item. You will want to find the right balance so that there are enough supplies for everyone who wants to enjoy the activity, but there aren't too many things so that it is unmanageable for the staff and volunteers. Also, scarcity of resources and supplies can often lead to more creativity!

Smithsonian Connections

- Resources from the Lemelson Center for the Study of Invention and Innovation
    - Featured Inventors: Various Stories and Blogs – http://invention.si.edu/search/inventors%20stories

- Resources from the Cooper-Hewitt National Design Museum:
    - Website: Design for the Other 90% – http://www.designother90.org/
    - Activity: *Ready, Set, Design!* - http://www.cooperhewitt.org/2011/09/09/ready-set-design/

- Resources from the National Museum of American History
    - Collections: Graphic Arts Patent Models – http://americanhistory.si.edu/collections/object-groups/patent-models-graphic-arts
    - Collections: Textiles and Sewing Machines Patent Models – http://americanhistory.si.edu/collections/object-groups/patent-models-textile-and-sewing-machines

About Spark!Lab

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SPARK!LAB™

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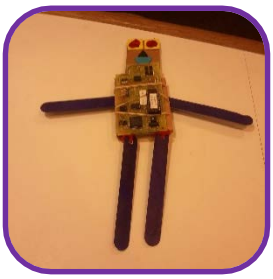
Grab Bag Inventing Images for Inspiration



Grab Bag Inventing Challenge Cards

You live in a place that has both a rainy season and a dry season.

Invent something that…

Photo by Rob and Stephanie Levy

allows you to collect water in the rainy season so you can use it during the dry season.

Your farm is several miles from the nearest market.

Invent a vehicle…

that can transport your crops from farm to market safely and efficiently.

Your best friend uses a wheelchair to get around.

Invent something…

he or she can use to easily carry things to your house for a sleepover.

You live in an area of the world that has a lot of tornadoes.

Invent something that…

can warn you a tornado is coming, even if the electricity goes out.

You have to walk from classroom to classroom during the school day. Since you are moving all the time, you sometimes lose things.

Invent something that…

makes it easier to keep track of all of your supplies.

Invent-A-Vehicle

A participant tests her vehicle

Invent-A-Vehicle Overview

The Big Idea

Participants work together to build a vehicle to solve a specific problem. Vehicles are constructed from reusable materials and components on a scale that encourages collaboration, imagination, and functional testing. The larger the variety of materials available, the more creative innovation is possible! This activity works well with individuals as well as groups.

Facilitation Level: Moderate

- As a facilitator, you will need to manage the supplies and keep the activity area safe for participants.

- You also may need to assist participants in working through trouble spots or frustrations.

- If you are using this as a group activity, you will need to structure the activity, assign challenges, and lead debriefs. (Please see the **Working with Groups** section below for more specific details.)

- You do not need any prior engineering, building, or design experience to facilitate this activity effectively. You should, however, try the activity out yourself before facilitating it with a group to ensure that you have a comprehensive understanding of the activity and how the materials work.

Average Activity Length

- 15-30 minutes for individuals
- 20-40 minutes for structured groups

Activity Supplies and Materials*

- Vehicle supplies
  - ¾" PVC pipe, various lengths (recommended lengths: 1', 2', and 4'; 6-8 of each length)
  - ¾" PVC connectors, various styles and shapes (T, X, elbow)
  - Flexible tubing, various lengths (recommended lengths: 2' and 4'; 2-3 of each length)
  - Wheels, various sizes (recommended sizes: 6", 8", 12"; lawn mower or hand truck wheels work well)
  - Wheel connectors (see fabrication instructions on page 10)
    - ½" steel bolts, 5" long (threads along the entire shaft)
    - ½" steel nuts
    - ½" steel washers
    - ¾" to 1" PVC connectors
    - ¾" 4-way (X-shaped) PVC connectors
    - Epoxy and PVC primer and cement
- Challenge Cards which offer building ideas and related images** [each printed to be at least 8 ½" x 11" in size]:
  - Build a prototype, or model, of a vehicle that farmers can use to move their crops from their farm to the market quickly and safely.
  - Build a prototype, or model, of a vehicle that can clear snow from roads in the winter and spread asphalt on roads in the summer.
  - Build a prototype, or model, of a delivery vehicle that can move easily and safely through a busy city.
  - Build a prototype, or model, of a vehicle that can ride on land or in the water.
  - Build a prototype, or model, of a vehicle with fewer than 4 wheels.
  - Build a prototype, or model, of a vehicle that fits only one person.
- Optional items
  - Cardboard
  - Buckets
  - Dowels
  - Large recyclable items
  - Sketching materials (pencils, paper, whiteboards, markers)

*A note about Activity Supplies and Materials

If you are unable to secure the exact supplies listed above, you may explore similar items. The important thing is to provide materials that can be easily connected to one another, and to provide a collection of items that may be used as wheels. The materials should be of a scale that is large enough to encourage meaningful collaboration and testing. It is important that the materials allow participants to have success in creating vehicles as described in the Challenge Cards.

You will also want to have some way to organize the different supplies and materials. Simple plastic bins or boxes work well. It is best to keep the PVC pipe, wheels, and other materials in separate containers so it is easy for participants to see the different resources that are available to them.

**Challenge Cards can be found at the end of this training guide.

Outcomes

By participating in this activity, individuals will:

1) understand that inventions solve problems
2) set a goal and use problem-solving and critical-thinking skills to reach it
3) engage in the invention process through a hands-on design and building activity
4) understand that failure is often part of the invention process

Related Invention Process Steps

Have a great idea for an invention.

(Optional step) Draw pictures and diagrams of your invention to figure out how it might work.

Build a prototype or model of your idea.

Test your invention.

Keep improving your idea.

Talk about your invention. (This applies mostly when you are working with groups and include debriefs in the activity.)

Invent-A-Vehicle Implementation

Facilitation Ideas

- Encourage participants to choose a Challenge Card that interests them. If they are hesitant to choose a challenge, let them know it is ok to build something else. There is no "right" way to do this activity.

- Some questions to ask participants while they are working with this activity include:
  - What kind of vehicle are you building?
  - Are you following one of the ideas on the Challenge Cards or is this your own idea?
  - Who might use your vehicle? Why might they use it?
  - Where would it be used—here or in another part of the world?
  - Are you inspired by a vehicle that already exists, or is this from your imagination?
  - If you were going to build this vehicle for real, what materials would you use?
  - Can you tell a story about your vehicle?
  - (For older participants) How might you bring this vehicle to market to sell it?

- Often participants build with no specific end goal. This is ok; they are learning how the building material functions and what its strength and limitations are, all while being creative. Sometimes asking questions like those above will encourage participants to consider their design more thoughtfully and will direct their building.

- If a participant is frustrated with his/her vehicle or feels he/she is doing it "wrong," offer assurance that there is no right or wrong way to build. Ask what is being attempted and offer an idea or two to get the participant back on track. **Do your best to avoid building the vehicle for him/her.** The best strategy is to ask questions that help the participant to identify a new strategy or next step. (What happens if you try this? What if you added something here?)

- You may occasionally find someone taking a creation away from another participant to "do it right" or "fix it." If that happens, re-involve the excluded participant by starting to build something yourself, invite the individual to join you, and then encourage him/her to finish the vehicle.

Working with Groups

- Invent-A-Vehicle can be used very effectively with structured groups of participants.

- You will want to split larger groups into several smaller groups of 3-6 people each. The total number of people who can participate will depend on the amount of supplies you have. You will want to be sure that all groups can successfully accomplish the activity. As a general guideline, each group should have access to at least 2 wheels, and at least 2 pieces of PVC pipe in each length. Having additional items like cardboard, buckets, dowels, and larger recyclable items can also be very helpful with larger groups.

- It is best if you pool all of the supplies together rather than split up the supplies for each group. Part of this activity—with all participants, but especially with groups—is providing them opportunities to collaborate across groups, to trade or barter supplies, and to work with limited resources. This models how real inventors work.

- There are several ways to structure the activity:
    - You can specify that the groups brainstorm ideas and sketch before they can begin building. This is recommended only if the group has at least 20 minutes to spend on the entire activity.
    - You can select a Challenge Card and give all of the groups the same challenge. At the end, debrief the activity and have each group explain how it solved the challenge. It is very likely that the designs will all look different, which can lead to a rich discussion about how there are many ways to solve a single problem.
    - Another option is to give each group a different Challenge Card. Again, you will want to debrief at the end and have each group present its design.
    - During the debrief period, ask the groups what was challenging, if their design changed during the process, and how they overcame obstacles. Reinforce that the work they did during this fun activity is what real inventors do!

- Many of the strategies listed in the **Facilitation Ideas** section above can also be used when working with groups.

Other Tips

- You can provide sketching materials (paper and pencils or whiteboard and markers) and challenge participants to sketch their idea before they build it. Sketching can also be a useful tool during the testing and tweaking phases.

- The optional materials listed above (cardboard, buckets, dowels, large recyclable items) can provide additional opportunities for participants. Often, participants will use these items to create cargo holds, steering wheels, and other "extras" for their vehicles.

- Invent-A-Vehicle is a great transactive activity—one that can change over time. Instead of breaking down a vehicle once participants leave, try keeping it up (or at least part of it) and allow others to add onto or otherwise alter it. Most inventors build off of existing ideas; this strategy allows participants to engage in this same type of iterative process.

- The transactive quality of the activity can also yield other interesting results. Participants often:
    - feel less reliant on "authority" to answer questions or design their vehicle
    - exhibit a higher level of engagement and deeper investigation
    - spend a longer amount of time on the activity
    - define their own success and make their own meaning
    - generate particular types of question: "How can I get my vehicle to…?," "What if I tried…?," "Why does it…?," and "What makes it…?"

Safety and Maintenance

- There is little maintenance with this activity, but it is important to routinely inspect the condition of all materials. Any components that are excessively worn, broken, or have sharp edges should be promptly removed or replaced.

- You may want to experiment with the amount of materials you have out at any one time. You may discover that the activity works better when you have out only a few items. You will want to find the right balance so that there are enough items for everyone who wants to enjoy the activity, but there aren't too many pieces so that it is unmanageable for you and your staff.

Smithsonian Connections

- Resources from the Lemelson Center for the Study of Invention and Innovation
    - Featured Inventor: Anthony Levandowski – http://invention.si.edu/podcast-anthony-levandowski-competes-inventing
    - Articles, Blogs, and Transportation-related Collections – http://invention.si.edu/tags/transportation

- Resources from the National Museum of American History (NMAH)
    - Exhibition: *America on the Move* – http://amhistory.si.edu/onthemove/
    - Collections: Transportation-related items at NMAH – http://tinyurl.com/ky228b2

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Invent-A-Vehicle Images for Inspiration

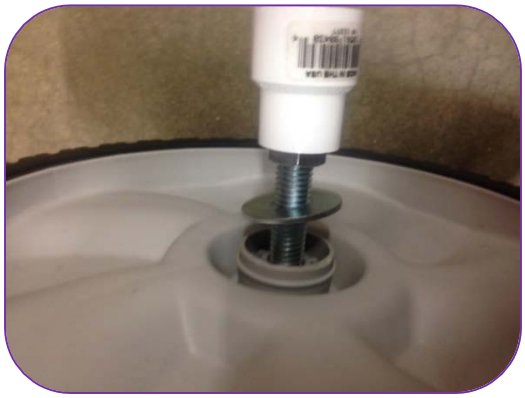
Invent-A-Vehicle Wheel & Axle Build Instructions

Materials

- Wheel (various diameter)
- ½” steel bolt, 5” long (threads along the entire shaft)
- 4 – ½” steel nuts
- 2 – ½” steel washers
- 2 – ¾” to 1” PVC connectors
- ¾” 4-way (X-shaped) PVC connectors
- Epoxy and PVC primer and cement

The Build

- Insert bolt into a ¾” to 1” connector, as shown.
- Screw on one nut to secure connector.
- Apply a small amount of epoxy on bolt threads to lock nut in place.



- Place one washer on bolt and slide into the wheel, as shown.

- On the opposite side of the wheel, place the other washer and thread two ½” nuts onto the bolt.
- Tighten the nuts on the bolt, but be sure the wheel can still spin freely.
- Apply a small amount of epoxy on bolt and nuts to lock them in place.

- Slide narrow side on a ¾” to 1” PVC connector onto bolt, as shown.

- Screw the final nut onto the bolt and tighten. Apply a small amount of epoxy on threads to secure the nut in place.

- Insert one 4-way PVC connector onto each end of the axle, as shown. Some sanding of the 4-way connector may be needed for a secure fit.
- Cement the 4-way connectors in place with epoxy or PVC cement.
- Allow PVC cement to dry for 48 hours before use.

Invent-A-Vehicle Challenge Cards

Build a prototype, or model, of a vehicle that farmers can use to move their crops from their farm to the market quickly and safely.

EXPLORE IT

Inventors often explore inventions that already exist before they begin designing their own creations. This bike is designed to transport goods to and from market. How might your vehicle be the same or different?

Build a prototype, or model, of a vehicle that can clear snow from roads in the winter and spread asphalt in the summer.

THINK iT

Inventors often work together. Collaboration can lead to exciting and sometimes unexpected outcomes! What happens when you collaborate on inventing a new vehicle?

Build a prototype, or model, of a delivery vehicle that can move easily and safely through a busy city.

SELL iT

Once they create something new, inventors have to convince other people to try their inventions. How do you think you would sell your new delivery vehicle?

Build a prototype, or model, of a vehicle that can ride on land or in the water.

SKETCH IT

Many inventors sketch their ideas before they begin building a prototype. Try sketching your design first. Does it look different from your prototype? How did your idea change once you started building?

Build a prototype, or model, of a vehicle with less than 4 wheels

TRY IT

Once they have built a prototype, inventors usually test their design to see if it works. They also use test to learn how they can improve what they have built. How does your vehicle work? Does it operate the way you thought it would?

Build a prototype, or model, of a vehicle that fits only one person.

Most inventors improve on their invention many times before getting it just the way they want it. How can you tweak or adjust your original design to make your vehicle better?

Mobile Masterpieces

A Mobile Masterpiece made of felt leaf shapes

Mobile Masterpieces Overview

The Big Idea

Artists take properties from science and incorporate them into their work. The mobile is a great example of science merging with art, and a great way to express inventive thought and creativity. With the use of scales and balance, the mobile takes on great beauty. This activity allows participants to explore the scientific principles of balance and scale, and create their own inventive mobiles.

Facilitation Level: Moderate to High

- As a facilitator, you will need to manage the supplies and keep the activity area safe for participants.

- You also may need to assist participants in working through trouble spots or frustrations. For example, tying knots in the string can be especially challenging for younger participants so you may need to assist with this part of the activity.

- If you are using this as a group activity, you will need to structure the activity, assign challenges, and lead debriefs. (Please see the **Working with Groups** section below for more specific details.)

- You do not need any prior engineering, art, or design experience to facilitate this activity effectively. You should, however, try the activity out yourself before facilitating it with a group to ensure that you have a comprehensive understanding of the activity and how the materials work.

Average Activity Length

- 15-30 minutes for individuals
- 20-40 minutes for structured groups

Activity Supplies and Materials*

Almost any type of craft, office, or household supply can be used with Mobile Masterpieces. Recyclable materials and simple (and safe) hardware can also be incorporated. Here is a suggested—but by no means exclusive or exhaustive—list of materials:

- Hangers
- Sturdy string or yarn
- Balance scale
- Hole punches
- Scissors
- Construction paper, felt and/or other materials kids can cut shapes/designs out of
- Stencils
- Objects of different sizes/weights
    - Assorted washers
    - Beads with large lacing holes
    - Felt shapes
    - Buttons with large holes
    - Pasta
    - Wooden pieces
- Images of mobiles**
    - Book mobile
    - Fish mobile (Alexander Calder)
    - Owl mobile
    - Raindrop mobile
    - Stainless Stealer mobile (Alexander Calder)
    - Waterfall mobile
- Frames to display images of mobiles
- Activity Instruction Sign** [printed to be at least 11” x 14” in size]:
    - A mobile is a type of kinetic (or moving) sculpture. Artists create mobiles with lots of different kinds of objects. The weight of the objects is balanced to help keep the mobile level.

      1) Select the objects you would like to use on your mobile.
      2) Compare the weights of the objects. Will they be able to keep your mobile balanced?
      3) Tie each object onto a piece of string. Each string should only have one object on it.

4) Tie the strings along the coat hanger. Tie them loosely enough so that you can move them.
5) Is your mobile balanced? Make any adjustments that might be needed.

*A note about Activity Supplies and Materials

It is critical to have a "base" for the mobile, as this is the element from which the items will hang. Wire coat hangers work especially well. Other options include wooden dowels or craft sticks tied together in a + formation. The other supplies and materials listed above are simply suggestions. Almost any type of craft, office, or household supply can be used in Mobile Masterpieces. You will want to have items of different weights to allow participants to experiment with different hanging configurations. It is also important to provide materials that can be easily used by participants of all ages, and that allow participants to have success in creating mobiles.

You will also want to have some way to organize the different supplies and materials. Simple plastic containers work well. It is best to separate core supplies like coat hangers, scissors, and hole punches from the other items. You will also want to have a trash can nearby to make clean-up for both you and your participants easy.

**Images of mobiles and the Activity Instruction Sign can be found at the end of this training guide.

Outcomes

By participating in this activity, participants will:

1) exercise inventive thinking skills
2) set a goal and use problem-solving and critical-thinking skills to reach it
3) begin to identify themselves as inventive thinkers and problem-solvers
4) experiment with and begin to understand the opportunities and limitations of a wide range of materials
5) think about the intersection between art and science in invention and innovation

Related Invention Process Steps

Have a great idea for an invention.

Investigate inventions, ideas, and designs that already exist.

Build a prototype or model of your idea.

Talk about your invention. (This applies mostly when you are working with groups and include debriefs in the activity.)

Mobile Masterpieces Implementation

Facilitation Ideas

- A mobile is a type of kinetic sculpture constructed to take advantage of the principle of equilibrium. The objects hang from strings and balance each other, so that the mobile remains more or less horizontal. Each string has only one object attached, giving the objects freedom to move independently.

- The biggest challenge participants will have is selecting objects that will keep the mobile balanced. You can encourage individuals to use the scale to weigh their various selections to ensure that they have the appropriate balance of objects.

- One area of potential frustration for participants lies in tying the strings on the coat hangers. Younger participants especially may have difficulty with this part of the activity. You should feel free to encourage participants to seek help from others when needed.

- Another challenge for participants can be getting the objects spaced properly along the hanger. It is best to tie the strings tight enough so that they are not sliding along the hanger, but not so tightly that they cannot be repositioned if needed. Using 4-5 strings is generally the best strategy.

- You can use the images of artwork (provided at the end of this training guide) to inspire participants and to serve as a jumping off point for their creations. It is best to display only one or two images at a time. More images can be confusing or overwhelming. Depending on your participants and the structure of your program, you may also encourage participants to conduct online research about mobiles within museum collections. You can share the Smithsonian Connections links (below) or challenge them to find mobiles in local museum collections.

- If you choose to display more than one image of artwork, you may want to offer two very different pieces. This can provide participants with varied inspiration and often results in more creative and innovative masterpieces!

- Other than ensuring that the mobile is balanced, there is not a "right" or "wrong" way to approach this activity. Participants should be encouraged to be as creative as possible. This offers a great opportunity for them to explore different materials and learn about the benefits (or drawbacks) of working with different items.

- You may occasionally find someone taking a creation away from another participant to "do it right" or "fix it." If that happens, re-involve the excluded participant by starting a new creation and then invite him/her to continue working on it.

Working with Groups

- Mobile Masterpieces Machines can be used with structured groups, though you will probably want to limit the number of people working on this activity at one time to 6-8. If the group is larger, you can split into smaller groups. Assign one group to Mobile Masterpieces, and other groups to other activities. If there is time, groups can rotate through each of the activities.

- It is best if you pool all of the supplies together rather than split up the supplies for each group. Part of this activity—with all participants, but especially with groups—is providing them opportunities to collaborate across groups, to trade or barter supplies, and to work with limited resources. This models how real inventors work.

- Group members will work individually during this activity.

- There are two ways to structure the activity for groups:
    - First, you can give all participants the same challenge (e.g. create a mobile inspired by one of the images provided or create a mobile using items of only one color). At the end, debrief the activity and have each person explain how he/she solved the challenge. It is very likely that the designs will all look different, which can lead to a rich discussion about how there are many ways to solve a single problem.
    - A second option is to allow everyone in the group to define their own challenge and to create a mobile based on their own idea. Again, you will want to debrief at the end and have each person present his/her design.
    - During the debrief period, ask participants what was challenging, if their designs changed during the process, and how they overcame obstacles. Reinforce that the work they did during this fun activity is what real inventors do!

- Many of the strategies listed in the **Facilitation Ideas** section above can also be used when working with groups.

Other Tips

- This activity is very flexible so it is ok to change the materials from time to time. Other than basic supplies like coat hangers (or other base materials), scissors, hole punches, and string, there is nothing that is specifically required for this activity. Just be sure that all items can easily be strung on the mobile with existing holes or holes that can be punched.

- When using Mobile Masterpieces, it is best not to have another activity that uses consumable supplies out at the same time. Maintenance and clean-up can be challenging when there are multiple activities to monitor and replenish.

Safety and Maintenance

- The biggest challenge with this activity will be to keep the supplies orderly. In making their mobiles, participants will often use a variety of supplies and leave scraps behind. Encourage participants to keep larger scraps for reuse, and to throw away smaller scraps.

- You will need to check the material supply frequently to ensure that there is always a variety of things out with which participants can create. But you may want to experiment with the amount of materials out at any one time. You may discover that the activity works better when you have out only a few of each different item. You will want to find the right balance so that there are enough supplies for everyone who wants to enjoy the activity, but there aren't too many things so that it is unmanageable for the program facilitators.

- You will want to tidy up the activity table periodically. Often when you model this behavior, participants will also begin to clean their area.

Smithsonian Connections

- Resources from the Lemelson Center for the Study of Invention and Innovation
    - Featured Inventor: Arthur Ganson – http://invention.si.edu/innovative-lives-arthur-ganson-metaphysics-motion
    - Podcast: Invention and Art – http://invention.si.edu/podcast-jessica-darraby-invention-art-or-vice-versa
    - Blog: Reinstallation of Alexander Calder sculpture – http://invention.si.edu/alexander-calders-gwenfritz-rededicating-modernist-icon

- Resources from the Smithsonian American Art Museum (SAAM)
    - Collections: Alexander Calder works at SAAM – http://americanart.si.edu/collections/search/artwork/results/?q=alexander%20calder

- Resources from the Hirshhorn Museum and Sculpture Garden (HMSG)
    - Collections: Alexander Calder works at HMSG – http://hirshhorn.si.edu/collection/alex-calder/#collection=alex-calder
    - Program recording: Alexander Calder as an engineer – http://hirshhorn.si.edu/collection/programs-calendar/#detail=/bio/fgt-alexander-calders/&collection=programs-calendar

About Spark!Lab

Spark!Lab is the flagship educational initiative of the Smithsonian's Lemelson Center for the Study of Invention and Innovation. It is a hands-on invention workspace where participants can learn about and engage in the history and process of invention. Participants to Spark!Lab can participate in a variety of activities that illustrate the invention process and appeal to varied learning styles, ages, and abilities. Activities also allow participants to practice 21st century skills, like collaboration, problem-solving, and critical thinking, and incorporate a variety of disciplines including history, science, engineering, and art. To learn more, visit http://invention.si.edu/try/sparklab.

Mobile Masterpieces Images for Inspiration

Mobile Masterpieces Images of Mobiles & Activity Instruction Sign

Fish

ARTIST:

Alexander Calder, American, b. Lawnton, Pennsylvania, 1898–1976

MEDIUM:

Painted metal rod, wire, metal, plastic, wood, glass and ceramic fragments

DIMENSIONS:

16 1/4 x 48 1/8 x 4 1/2 in. (41.3 x 122.2 x 11.4 cm)

TYPE:

Sculpture

DATE:

(1944)

CREDIT LINE:

Hirshhorn Museum and Sculpture Garden, Smithsonian Institution, Washington, DC, Gift of Joseph H. Hirshhorn, 1966

ACCESSION NUMBER:

66.785

PROVENANCE:

Jh Purchased From Diamond, Harold, New York 1963

EXHIBITION HISTORY:

SMITHSONIAN AMERICAN ART MUSEUM, Smithsonian Institution, Washington, DC. Grand re-opening exhibition, 1 July 2006-4 July 2007.

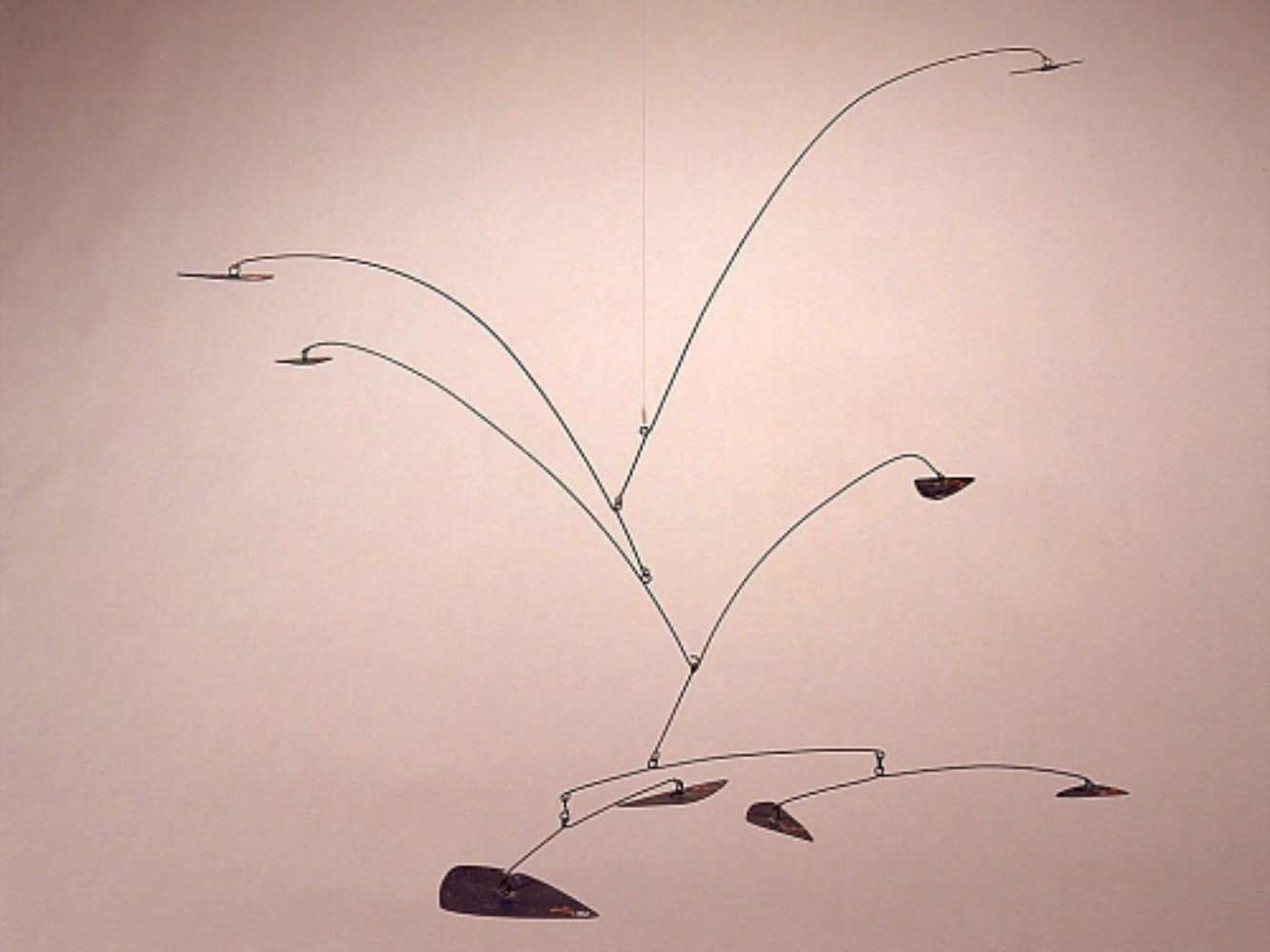
HIRSHHORN MUSEUM AND SCULPTURE GARDEN, Smithsonian Institution, Washington, DC. "Over, Under, Next: Experiments in Mixed Media, 1913-Present," 18 April-8 September 2013, no cat.

SCHOOL:

American Abstraction (Mid-Century)

DATA SOURCE:

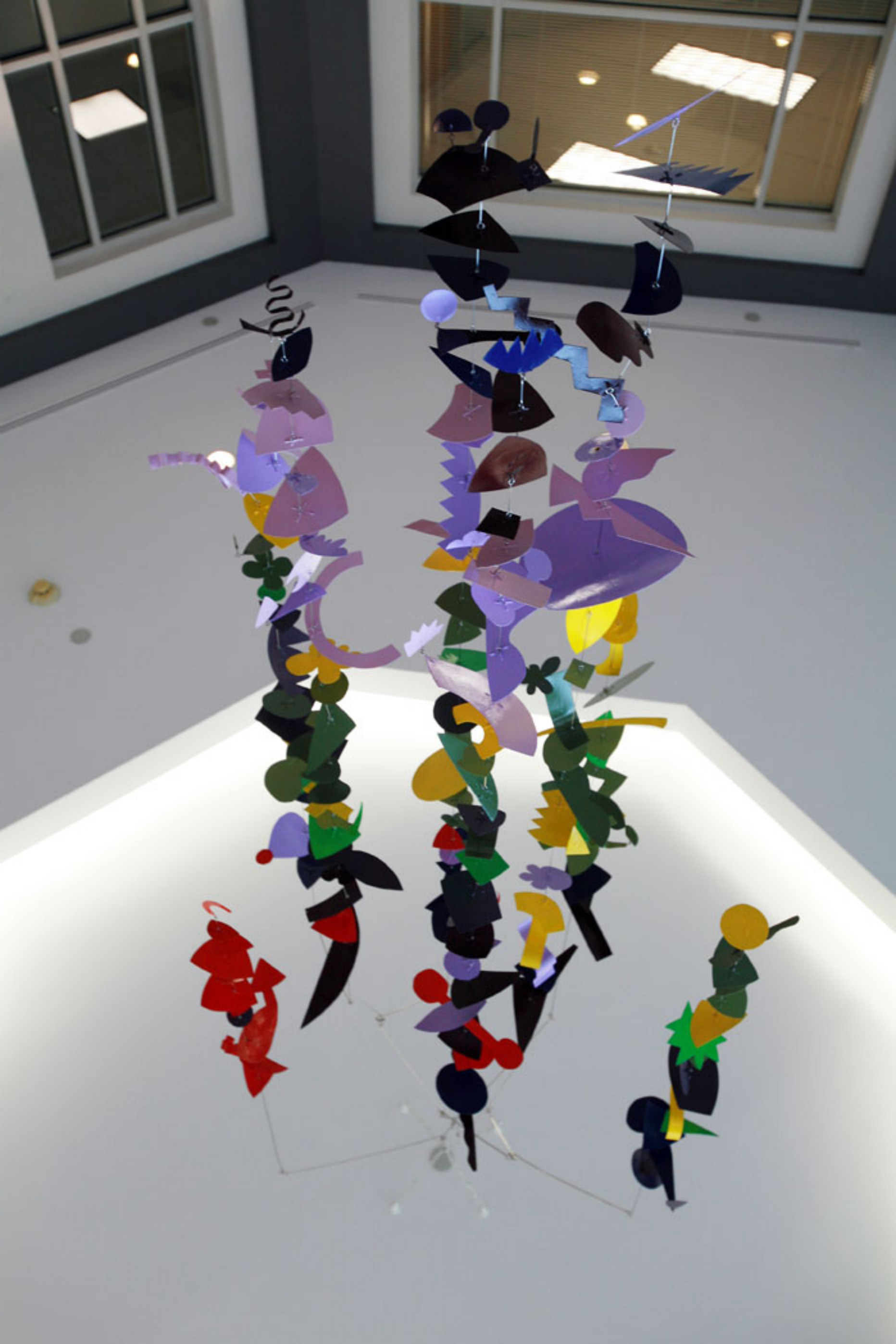
Hirshhorn Museum and Sculpture Garden



The Stainless Stealer (Maquette)

ARTIST:
Alexander Calder, American, b. Lawnton, Pennsylvania, 1898–1976
MEDIUM:
Painted sheet steel and wire
DIMENSIONS:
28 1/8 X 20 1/8 IN. (71.6 X 51.0 CM.) VARIABLE, MEASURED FLAT
TYPE:
Sculpture
DATE:
(1966)
CREDIT LINE:
Hirshhorn Museum and Sculpture Garden, Smithsonian Institution, Washington, DC, The Joseph H. Hirshhorn Bequest, 1981
ACCESSION NUMBER:
86.741
SCHOOL:
American Abstraction (Mid-Century)
DATA SOURCE:
Hirshhorn Museum and Sculpture Garden


fine art
america



Shaping Space

Participants crawling through a tunnel they made with the Shaping Space activity

Shaping Space Overview

The Big Idea

Structures are built and engineered according to their intended purpose. Participants use imagination, problem-solving, and the construction materials provided to find inventive ways to shape spaces to meet architectural challenges.

Facilitation Level: Low

- As a facilitator, you will need to manage the supplies and keep the activity area safe for participants.

- You also may need to assist participants in working through trouble spots or frustrations.

- If you are using this as a group activity, you will need to structure the activity, assign challenges, and lead debriefs. (Please see the **Working with Groups** section below for more specific details.)

- **You do not need any prior engineering, building, or design experience to facilitate this activity effectively.** You should, however, try the activity out yourself before facilitating it with a group to ensure that you have a comprehensive understanding of the activity and how the materials work.

Average Activity Length

- 15-30 minutes for individuals
- 20-40 minutes for structured groups

Activity Supplies and Materials*

- Straws and Connectors (this is a commercial product)
- White boards with dry erase markers and eraser
- Challenge Cards which offer building ideas and related images** [each printed to be at least 8 ½" x 11" in size]:
    - Can you shape a space ...that is wide at the bottom and gets narrower at the top?
    - Can you shape a space ...that is square on the bottom and round at the top?
    - Can you shape a space ...that is as tall (or taller) than you are?
    - Can you shape a space ...that is round?
    - Can you shape a space ...that is neither round nor square?
    - Can you shape a space ...for a mobile sleeping unit that can be moved each day?
    - Can you shape a space ...for a home that is on the ground in the dry season and floats during heavy rainfalls?
    - Can you shape a space…for an indoor skateboarding park?
    - Can you shape a space ...for the sports stadium of the future?
    - Can you shape a space…for your perfect school?

*A note about Activity Supplies and Materials

If you are unable to secure the Straws and Connectors product as suggested, you may explore a similar building product. The important thing will be to provide materials that can be easily used by participants of all ages. Materials should connect easily and allow participants to have success in creating structures as described in the Challenge Cards.

You will also want to have some way to organize the materials. Simple plastic containers work well. It is best to separate the straws from the connector pieces to make it easy for participants to see the materials that are available to them.

**Challenge Cards can be found at the end of this training guide.

Outcomes

By participating in this activity, individuals will:

1) engage in the invention process through a hands-on building activity
2) solve a problem by designing and building a structure for a particular purpose
3) understand opportunities and limitations presented by a particular building material

4) gain an increased awareness of how a building's structure can influence what happens inside of it or what it can be used for

Related Invention Process Steps

Have a great idea for an invention.

Investigate inventions, ideas, and designs that already exist.

Build a prototype or model of your idea.

Keep improving your idea.

Talk about your invention. (This applies mostly when you are working with groups and include debriefs in the activity.)

Shaping Space Implementation

Facilitation Ideas

- Encourage participants to choose a Challenge Card that interests them. If they are hesitant to choose a challenge, let them know it is ok to build something else. There is no "right" way to do this activity.

- Encourage participants to sketch their ideas on the white boards before beginning to build or during the building process, especially if they are having difficulties. Sketching can be a great problem-solving tool.

- Some questions to ask participants while they are working with this activity include:
  - What kind of structure are you building?
  - Who might use your structure?
  - Where would it be located—here or another part of the world?
  - If you were going to build this structure for real, what materials would you use?
  - Can you tell a story about your building?
  - Are you inspired by a structure that already exists, or is this from your imagination?

- Often participants will just build with no specific end goal. This is ok; they are learning how the building material functions and what its strength and limitations are, all while being creative. Sometimes asking questions like those above will encourage participants to consider their structure more thoughtfully and will direct their building.

- If a participant is frustrated with his/her structure or feels he/she is doing it "wrong," offer assurance that there is no right or wrong way to build. Ask what is being

attempted and offer an idea or two to get the participant back on track. (What happens if you try this? What if you added something here?)

- In addition to the ideas on the Challenge Cards, you can prompt participants to build more familiar structures such as bridges, skyscrapers, and schools. This is a great way to talk about local or regional landmarks and have participants try to improve on the designs of structures with which they are most familiar.

- You may occasionally find someone taking a creation away from another participant to "do it right" or "fix it." If that happens, re-involve the excluded participant by starting to build something yourself and then hand it to him/her to continue working on.

Working with Groups

- Shaping Space can be used very effectively with structured groups.

- You will want to split larger groups into several smaller groups of 3-6 people each. The total number of people who can participate will depend on the amount of supplies you have. You will want to be sure that all groups can successfully accomplish the activity.

- It is best if you pool all of the supplies together rather than split up the supplies for each group. Part of this activity—with all participants, but especially with groups—is providing them opportunities to collaborate across groups, to trade or barter supplies, and to work with limited resources. This models how real inventors work.

- There are several ways to structure the activity:
    - You can specify that the groups have to brainstorm ideas and sketch before they can begin building. This is recommended only if the group has at least 20 minutes to spend on the entire activity.
    - You can select a Challenge Card and give all of the groups the same challenge. At the end, debrief the activity and have each group explain how it solved the challenge. It is very likely that the designs will all look different, which can lead to a rich discussion about how there are many ways to solve a single problem.
    - Another option is to give each group a different Challenge Card. Again, you will want to debrief at the end and have each group present its design.
    - During the debrief period, ask the groups what was challenging, if their design changed during the process, and how they overcame obstacles. Reinforce that the work they did during this fun activity is what real inventors do!

- Many of the strategies listed in the **Facilitation Ideas** section above can also be used when working with groups.

Other Tips

- Shaping Space is a great transactive activity—one that can change over time. Instead of breaking down each structure once participants leave, try keeping it up (or at least part of it) and allow others to add onto or otherwise alter it. It's fun to watch a structure evolve over the span of a day or so.

- The transactive quality of the activity can also yield other interesting results. Participants often:
    - feel less reliant on "authority" to answer questions or design their vehicle
    - exhibit a higher level of engagement and deeper investigation
    - spend a longer amount of time on the activity
    - define their own success and make their own meaning
    - generate particular types of question: "How can I get my vehicle to…?," "What if I tried…?," "Why does it…?," and "What makes it…?"

Safety and Maintenance

- The biggest challenge with this activity will be to keep the supplies orderly. Participants often like to dump all of the pieces out of the box onto the floor or table while they are working—but don't always like to put everything back before they leave!

- You may want to experiment with the amount of Straws and Connectors out at any one time. You may discover that the activity works better when you have out only a portion of your total supply. You will want to find the right balance so that there are enough pieces for everyone who wants to enjoy the activity, but there aren't too many pieces so that it is unmanageable for the facilitator.

- You will need to check the condition of the straws periodically. Straws will occasionally be bent during a construction project and may need to be removed if they are no longer usable.

Smithsonian Connections

- Resources from the Lemelson Center for the Study of Invention and Innovation
    - Blog: Bridges in the Archives – http://invention.si.edu/building-bridges-building-collections
    - Blog: Eco-cities – http://invention.si.edu/notes-director-eco-cities-can-they-work

- Resources from the National Museum of American History
    - Exhibition: *Within These Walls* – http://amhistory.si.edu/house/home.asp [AL1]

- Resources from the Freer-Sackler Gallery (FSG)
    - Collections: Architecture-related items at FSG – http://www.asia.si.edu/collections/edan/default.cfm?searchTerm=architecture&start=0&page=1

About Spark!Lab

Spark!Lab is the flagship educational initiative of the Smithsonian's Lemelson Center for the Study of Invention and Innovation. It is a hands-on invention workspace where participants can learn about and engage in the history and process of invention. Participants to Spark!Lab can participate in a variety of activities that illustrate the invention process and appeal to varied learning styles, ages, and abilities. Activities also allow participants to practice 21st century skills, like collaboration, problem-solving, and critical thinking, and incorporate a variety of disciplines including history, science, engineering, and art. To learn more, visit http://invention.si.edu/try/sparklab.

Smithsonian

Shaping Space Images for Inspiration

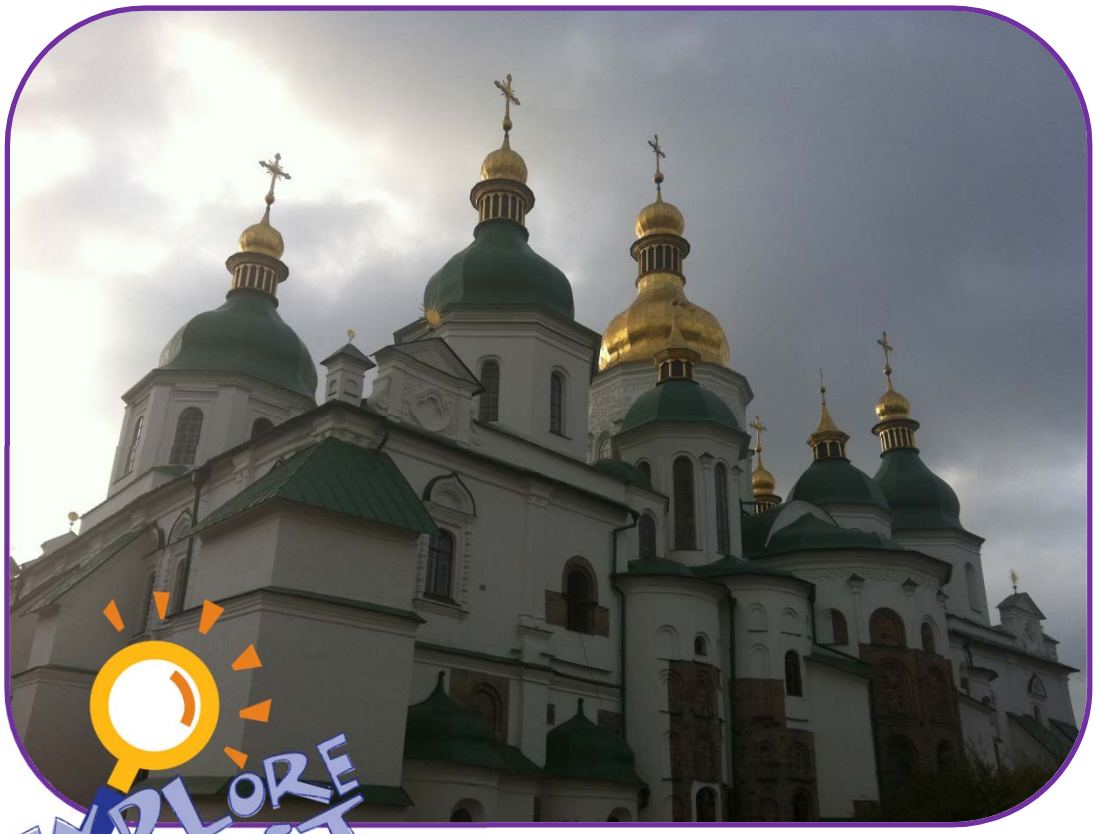
Shaping Space Challenge Cards

Can you shape a space…

CREATE IT

that is wide at the bottom and gets narrower at the top?

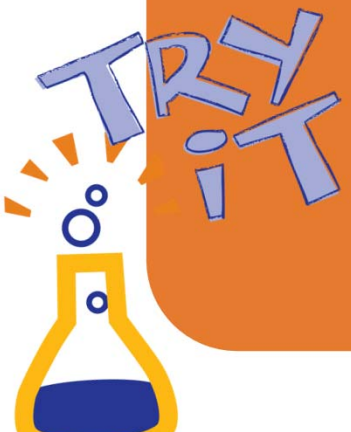
Can you shape a space…



that is square on the bottom and round on the top?

Can you shape a space...

that is as tall
(or taller)
than you?

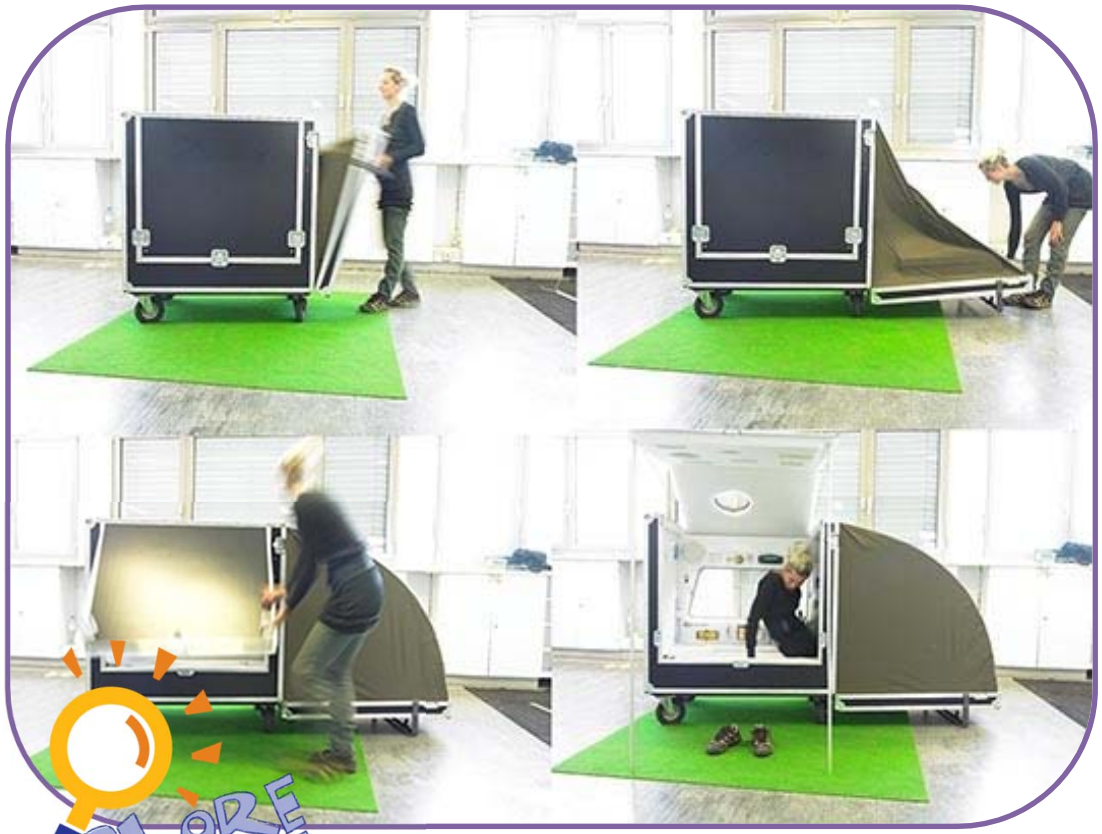


Can you shape a space…

that is round?

CREATE IT

Can you shape a space...



for a mobile sleeping unit that can be moved each day?

Can you shape a space…

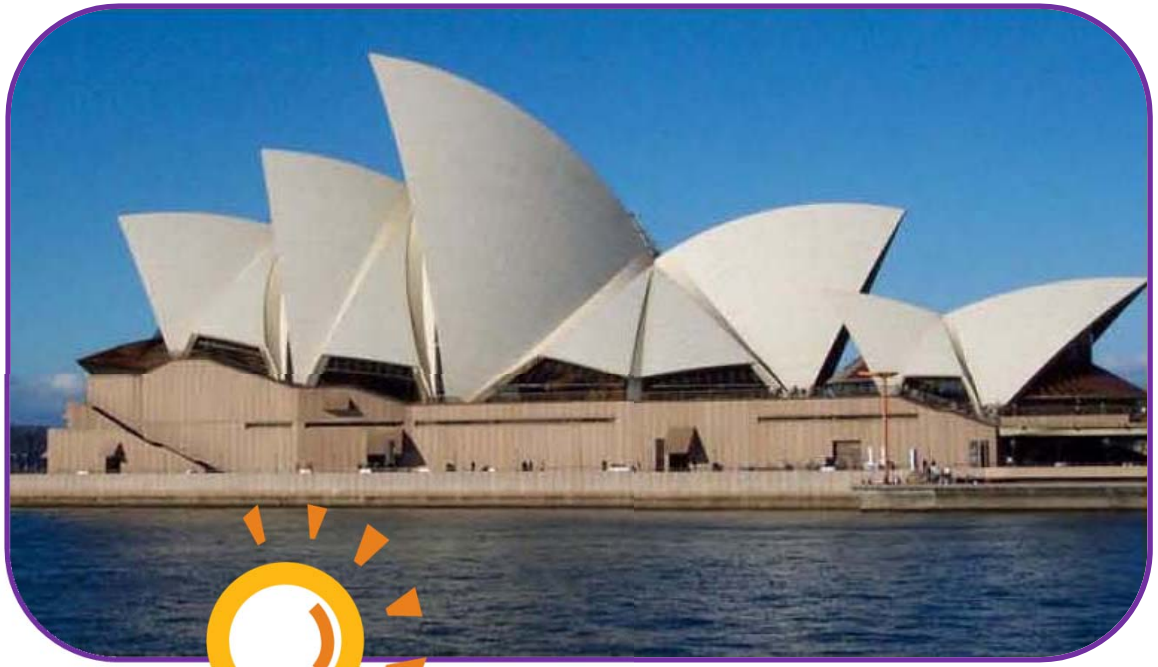
for a home that is on land in the dry season and floats during the rainy season?

Can you shape a space…

for the baseball stadium of the future?

CREATE iT

Can you shape a space…



that isn’t round or square?

Can you shape a space…

for an indoor skateboarding park?

Can you shape a space…

for your perfect school?

CREATE IT

About the Lemelson Center

Spark!Lab is the flagship educational initiative of the Jerome and Dorothy Lemelson Center for the Study of Invention and Innovation at the Smithsonian's National Museum of American History. Founded in 1995 through a generous gift from inventor Jerome Lemelson and his wife Dorothy, the Lemelson Center documents, interprets, and disseminates information about invention and innovation; encourages inventive creativity in young people; and fosters an appreciation for the central role that invention and innovation play in the history of the United States. Through public events, programs for families, publications, research opportunities, exhibitions, and its website (http://invention.si.edu/), the Lemelson Center:

- Records the past by preserving and increasing access to records and artifacts
- Broadens our understanding of history through research, discussion, and dissemination of ideas
- Looks toward the future by engaging young people in the exploration of invention and innovation

About Jerome Lemelson

Jerome Lemelson was one of America's most prolific inventors, with more than 600 patents to his name. His versatile mind produced inventions in communications and medical technologies, robotics and machine vision, and a variety of industrial processes. He also invented toys. In fact, Lemelson's first patent, issued in 1953, was for a variation on the propeller beanie, operated by blowing through a tube. (For a full list of Lemelson's patents, visit http://invention.si.edu/about/lemelsons-patents.)

Jerome Lemelson died in 1997 and is survived by his wife Dorothy and his two sons, Rob and Eric. All three are involved with the Lemelson Foundation, a private philanthropy that was established by the Lemelson family in the 1990s. The Foundation funds the activities of the Lemelson Center as well as the Lemelson-MIT program, Venture Well, and other U.S. and international programs.

About the National Museum of American History

Mission

Through incomparable collections, rigorous research, and dynamic public outreach, the National Museum of American History (NMAH) explores the infinite richness and complexity of American history. The museum helps people understand the past in order to make sense of the present and shape a more humane future.

The museum collects and preserves more than 3 million artifacts—all true national treasures—and takes care of everything from the original Star-Spangled Banner and Abraham Lincoln's top hat to Dizzy Gillespie's angled trumpet and Dorothy's ruby slippers from "The Wizard of Oz." The collections form a fascinating mosaic of American life and comprise the greatest single collection of American history.

Museum exhibitions explore major themes in American history and culture, from the War of Independence to the present day. *The Price of Freedom: Americans at War* surveys the history of U.S. military conflicts and examines ways in which wars have been defining episodes in American history. *America on the Move* immerses visitors in the sights, sounds, and sensations of transportation in the United States from 1870 to the present. Familiar favorites include *The American Presidency: A Glorious Burden, Within These Walls…*, and *First Ladies at the Smithsonian.*

The Museum hosts a full roster of public programs, from demonstrations, lectures, and tours to storytelling and festivals. Music programs offer performances by chamber music ensembles, a jazz orchestra, gospel choirs, folk and blues artists, Native American singers, dancers, and more.

The Museum's Archives Center houses a remarkable array of American history in documents,

photographs and other works. These include the Warshaw Collection of Business Americana, advertising histories of major U.S. corporations, and the Duke Ellington Collection—sheet music, correspondence and photographs related to the life and career of the great composer and jazz musician.

More than ever before, the National Museum of American History today shines new light on American history. The museum works to ensure that its collections, exhibitions, research, publications and educational programs all support the Museum's basic mission—to inspire a broader understanding of our nation and its many peoples—and to make its exhibitions and programs as accessible as possible to all visitors.

History

The National Museum of American History opened to the public in January 1964 as the Museum of History and Technology. It was the sixth Smithsonian building on the National Mall in Washington, D.C. Since then, some 4 million visitors a year have passed through the doors to enjoy the Museum's exhibitions, public programs, educational activities, collections, and research facilities. Millions more make virtual visits to the museum's website.

In 1980, the museum's name was changed to the National Museum of American History to better represent its basic mission—the collection, care and study of objects that reflect the experience of the American people.

In 2008, the museum completed a two-year, $85 million renovation of the building's center core, dramatically transforming the museum's architectural appeal while reorganizing and renewing the presentation of its extensive collections. The renovation project focused on three areas: architectural enhancements to the center core, including a grand staircase and a skylight; construction of a new Star-Spangled Banner gallery, and updates to the 44-year-old building's infrastructure.

Currently, the transformation of the museum is continuing with a major project to renew the building's 120,000-square-foot west exhibition wing.

To learn more about the museum, please visit http://americanhistory.si.edu/.