Invent It!

Time Estimate: 45-50 minutes

Overview

Students engage in four short activities to spark imaginative, inventive thinking. They take an "invention walk"; jumpstart their imaginations through brainstorming; play a game to learn how to think "outside the box"; and work collaboratively in "R & D" teams to meet a simple design challenge.

Science Standards

Students should:

Invention and Play Process

- Understand the role of troubleshooting, research and development, invention and innovation, and experimentation and problem solving.

The Scientific Enterprise

- Know that people of all backgrounds and with diverse interests, talents, qualities, and motivations engage in fields of science and engineering; some of these people work in teams and others work alone, but all communicate extensively with others.
- Know that the work of science requires a variety of human abilities, qualities, and habits of mind (e.g., reasoning, insight, energy, skill, creativity, intellectual honesty, tolerance of ambiguity, skepticism, openness to new ideas).

Technology/Engineering

- Communicate ideas through engineering drawings, written reports, and pictures.
- Know that the design process is a slow, methodical process of test and refinement.
- Know that the design process relies on different strategies: creative brainstorming to establish many design solutions, evaluating the feasibility of various solutions in order to choose a design, and troubleshooting the selected design.

Sources: *National Science Standards by NSF (National Science Foundation); National Technology Standards by(International Technology Education Association (ITEA); Mid-Continent Research for Education and Learning (MCREL).*

Materials & Preparation

Read through the lesson in its entirety and highlight sections you want to cover, given your particular time constraints and group of students.

- Optional: tape recorder for the "Invention Walk" activity.

See the concluding sample "Letter to Parents/Guardians". Send copies home to extend the activity outside of the classroom. Feel free to revise or to incorporate into an e-mail, newsletter, voicemail, or other correspondence with parents and guardians.

Procedure

Invention Walk

Time Estimate: 10-15 minutes

- Take students on a short "invention walk" around the school or classroom. Bring a tape recorder, if possible, and ask students to call out all of the things they see that have been invented.

- Ask students what they learned from the walk. No doubt they have realized that, apart from our natural world, every thing has been invented, and improved upon, by men and women.

  Every invention began as an idea in someone's mind. The pencil, the stapler, post-it notes, eyeglasses, barrettes, belts, computers, cars, Kleenex, light bulbs, water faucets, ceiling tiles, window blinds, paper clips, shoelaces, you name it, each one started out as an idea. Ideas for inventions are all around you. What hasn't been thought of yet? What hasn't been tried?

Imagination Jump-Start

Time Estimate: 10 minutes

- Write this quotation on the board: "Discovery consists of looking at the same thing as everyone else and thinking something different." —Nobel prize-winning biochemist Albert Szent-Gyorgyi. What do students think this means? Allow for many different interpretations.

- Draw a chalk dot on the blackboard, and ask the class: "What is this?" Hopefully, the class will come up with the obvious answer—a chalk dot on the blackboard—and then imagine further. Prompts, if needed: "What *else* could this be?... Use your imaginations... How about planet earth from outer space? How about a kernel of corn?... "

- Tell students that when this question was posed to a group of kindergartners, they easily thought of 50 different things a chalk dot could be: a bear's eye, a cigarette butt, the top of a telephone pole, a star, a pebble, a squashed bug, a rotten egg, a bellybutton, and so on.

- Ask for a show of hands. Agree or Disagree: "Imagination is more important than knowledge." Ask several students to explain their opinions. Then point out that this is a quote from Albert Einstein, one of the world's greatest physicists. Read his quotation in full: "Imagination is more important than knowledge. For while knowledge defines all we currently know and understand, imagination points to all we might yet discover and create."

- Pose two questions to the class and list answers on the board:
  1. What kinds of things dull or sap your imaginative powers?
  2. What kinds of things spark or strengthen your imaginative powers?

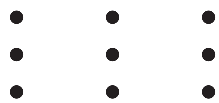
- Segue into the next activity. Feel free to draw from the sample script; change wording as needed to suit your age group of students:

  Inventors and other creative people are great at imagining, at thinking visually and spatially, and at seeing connections that others don't see. But all too often, in the process of growing up, we're encouraged to get "serious" and put play, make believe, and tinkering behind us. This advice can cripple our imaginations! Let's try a few activities that will strengthen our imaginative and inventive muscles.

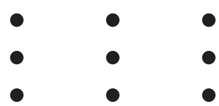
"Outside the Box": Connect-the Dot-Game

Time Estimate: 10 minutes

- Introduce the activity: "Here's your first inventive thinking challenge."
- Draw nine dots on the board, and ask students to replicate this pattern on their own sheets of paper:



- Pose the challenge: "Link up the nine dots using only 4 straight lines—and without lifting your pencil from the paper. You have three minutes." If any students have done this before, ask them not to reveal the solution to their classmates.
- Circulate among students, answering any questions, as they try to solve the problem.
- After three minutes, ask for a show of hands: "Who was able to solve this problem?" Invite a student to the board to show the solution. If no one came up with a solution, draw it yourself:



[depict solution]

Debriefing questions:

1. What assumption did most of us make that kept us from solving the problem?" (The lines must not extend beyond the boundaries set by the outer line of dots.)
2. Was this part of the instructions?
3. Why did you make this assumption?
4. What can this activity teach us? Solicit a range of answers: "What else?"

Sample wrap-up:

Our own assumptions and preconceived ideas—that there's a "right" and "wrong" way of doing something, for example—can limit our imaginations! In order to solve problems imaginatively, we often need to break through our assumptions and "think outside the box" – just like we needed to go beyond the boundary of the dots.

What Could this Be? Design Challenge

Time Estimate: 15 minutes

- Write this second quotation under the first: "Great discoveries and improvements invariably involve the cooperation of many minds." —Alexander Graham Bell, inventor of the telephone. Ask students why this might be true: Are two heads indeed better than one?

A common stereotype is that of the lone inventor. While inventors sometimes come up with unique ideas on their own, they typically discuss, test, and improve their ideas with others. For your next challenge, you'll have the chance to work together!

- Divide students into creative "R & D teams" of 3 or 4. Can students guess what "R & D" means? Explain that Research & Development is a crucial part of most businesses: the "brains" of the operation where new ideas are developed.

- Give each team a different everyday object: an eraser, a paper bag, a coat hanger, paper clip, coin, book, button, paper cup, ruler, deflated balloon, etc.

- Point out that inventors often see connections and possibilities that are not obvious to others. Then pose this creative challenge: "In 5 minutes, how many new, different, or unusual uses can you think of for your object? The team that comes up with the most ideas wins." Remind students that, in a brainstorm, all ideas count and no idea is too silly. "Ready, Set, Go!"

- Ask teams to report back to the class. Compile lists of design ideas on the board.

- Point out that product testing and evaluation are important parts of the invention process. Teams choose their favorite new use and put it to the test. Write the following questions on the board and ask teams to discuss and write down lists of answers:
    - What is good about this idea?
    - What is not so good about this idea?
    - How could it be made even better?

Option: Hold an "Invention Convention". Teams name their invention and design signage explaining its new use. They should map out the process step by step, as in a technical manual. E.g., Does anything need to be assembled or folded? Are there any safety considerations?

- Teams present their inventions to the class and display these in a designated area of the room.

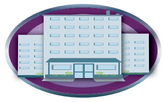
Optional Extensions

What If?

Time Estimate: 10-20 minutes

To find new ideas, inventors and other thinkers often ask themselves "what if" questions. The answers can lead to surprising creations. Students write a story or essay about one of the following "what if" questions. Invite them to come up with additional questions to add to the list.

- What if people could read each other's minds?
- What if people could travel through time?
- What if robots did all the work?
- What if water were more expensive than gold?
- What if you didn't have to go to school?



Question Collection[1]

Time Estimate: 15-20 minutes

- Beforehand, choose several objects to use in the brainstorm. These can be anything, familiar or unfamiliar, from an earthworm to a computer keyboard to a tool or gadget you use on the job that students might not be familiar with.

- Place a big piece of butcher block paper over the top of a table.

- Write the following quotation the board or a sheet of newsprint: "Wisdom begins in wonder." – Socrates. Ask students what they think this quotation means. Point out, if needed, that good thinkers ask good questions: they are bursting with curiosity!

- Ask students to gather around the table, give each student a pencil, and place an object in the center of the table (on top of the paper).

- Pose a challenge: "Being innovative requires having a curious, wondering mind. Let's see how many questions we can come up with about this object." This is a brainstorm so any question, however outlandish, is okay. Invite students to write questions on the paper all around the object.

  Examples:

  - Earthworm: Where does it live? Where does it go in the winter? Does it bite? How can you tell if it's a boy or a girl?...

  - Computer keyboard: How much does it weigh? Where was it made? Who made it, a man or woman? How much were they paid?...

- Congratulate students for their curiosity. Point out that open-mindedness and wonder are powerful mindsets to bring to any job.

- Explain how new ideas get generated in your company. What's the process for following up on new idea? Are new ideas tested? etc.

Select Resources

Invent America (**www.inventamerica.com**) is a nonprofit K-8 education program that helps children develop creative thinking and problem solving skills through inventing. They sponsor competitions and give awards for student inventions that solve everyday problems.

The Way Things Work by David Macaulay (Boston: Houghton Mifflin, 1998). This book has inspired many a young inventor. Text and numerous detailed illustrations introduce and explain the scientific principles and workings of hundreds of machines.

Check out this list of dozens of Web sites about girls and invention: **www.inventored.org/k-12/girlsinvent.html**

Dear Parents and Guardians,

In conjunction with **Take Our Daughters And Sons To Work® Day,** *our class has been exploring ways to spark imaginative, inventive thinking. I encourage you to extend this lesson and continue this discussion at home.*

Here are some sample questions/topics for you to discuss with your child:

1. "Wisdom begins in wonder," Socrates said. Do you take time to ask questions and "wonder" about things with your child? Even the simplest things can be objects of wonder.

Examples:

Earthworm: Where does it live? Where does it go in the winter? Does it bite? How can you tell if it's a boy or a girl?

Computer keyboard: How much does it weigh? Where was it made? Who do you think made it, a man or woman? How much were they paid?...

2. To find new ideas, inventors and other thinkers often ask themselves "what if" questions. Come up with some "what if" to explore with your child.

For example:

What if people could read each other's minds?

What if people could travel through time?

What if robots did all the work?

What if water were more expensive than gold?

What if you didn't have to go to school?

Thank you for your interest and participation.

Best,

Engineer It!

Time Estimate: 55-75 minutes

Overview

Working in teams, students become hands-on NASA engineers who are asked to design and create a prototype of an airbag landing system for future Moon voyages.

Science Standards

Students should:

Invention and Play Process

Understand the role of troubleshooting, research and development, invention and innovation, and experimentation and problem solving.

Design Process

- Understand the design process.
- Identify problems and develop solutions.
- Know how to model, prototype, and evaluate.

Science as Inquiry

- Understand the nature of scientific inquiry.
- Understand the scientific method.
- Design and conduct a scientific investigation (e.g., formulate hypotheses, design and execute investigations, interpret data, synthesize evidence into explanations, propose alternative explanations for observations, critique explanations and procedures).
- Understand that questioning, response to criticism, and open communication are integral to the process of science.

The Scientific Enterprise

- Know that people of all backgrounds and with diverse interests, talents, qualities, and motivations engage in fields of science and engineering; some of these people work in teams and others work alone, but all communicate extensively with others.
- Know that the work of science requires a variety of human abilities, qualities, and habits of mind (e.g., reasoning, insight, energy, skill, creativity, intellectual honesty, tolerance of ambiguity, skepticism, openness to new ideas).

Technology/Engineering

- Know that appropriate materials, tools, and machines enable us to solve problems.
- Communicate ideas through engineering drawings, written reports, and pictures.
- Know that the design process is a slow, methodical process of test and refinement.
- Know that the design process relies on different strategies: creative brainstorming to establish many design solutions, evaluating the feasibility of various solutions in order to choose a design, and troubleshooting the selected design.

Sources: *National Science Standards by NSF (National Science Foundation); National Technology Standards by(International Technology Education Association (ITEA); Mid-Continent Research for Education and Learning (MCREL).*

Materials & Preparation

Read through the lesson in its entirety and highlight sections you want to cover, given your particular time constraints and group of students.

- Photocopy one "Airbags on the Moon: Engineering Brief" for every 4 students.
- Photocopy one (2-sided) "Airbags on the Moon: Engineer It!" handout for every 4 students.
- Each 4-student team needs 7 balloons (simple party balloons, not mylar, of different shapes and sizes), a roll of masking tape, and one raw egg.
- Have several measuring sticks on hand.
- Optional: Supply a hand pump for blowing up balloons.
- Optional: Have on hand a digital camera to take pictures of teams engaged in the activity.

See the concluding sample "Letter to Parents/Guardians". Send copies home to extend the activity outside of the classroom. Feel free to revise or to incorporate into an e-mail, newsletter, voicemail, or other correspondence with parents and guardians.

Procedure

Scientific Method: It's Everywhere!

Time Estimate: 10-15 minutes

- Ask students if they've ever heard of the "scientific method". Can anyone explain what this is? Document answers on the board.

- Point out that science is about prediction and experimentation: "If I do this, I *think* this is what's going to happen…" Scientists and inventors have come up with a step-by-step method of predicting and experimenting. Write four simple terms on the board.

1. **Guess:** "If I do this, I guess this is what's going to happen."
2. **Test:** "Let's try out my idea and see what happens."
3. **Tell:** "Here's what happened and how it's the same/different from what I guessed."
4. **Guess again:** "If I change my idea, based on what I learned, here's what I think will happen."

Share the following anecdote:

Your baby brother or sister wants to get a cookie off the counter, but the counter's too high. What do they do?... They observe, they brainstorm ideas, they make a guess or prediction: "If I jump, I think I can reach the cookie." They test out their idea: They jump, but the cookie's still out of reach. What do they do? They guess again, based on what they learned: "I need to start higher. I think that if I drag this chair over near the counter, it will work…" This is the scientific method! We all use this method all the time, perhaps without even realizing it."

- Students work in pairs. Ask each pair to come up with an example of a time they recently put the scientific method into practice in their daily lives. Prompts, if needed: Did you guess, test, and figure out a better way to dribble a soccer ball? To keep your sandwich from getting soggy? To sleep in for 10 extra minutes and still get to school on time?

- Ask several student pairs to report back to the class.

Airbags on the Moon: The Egg-Drop Challenge[2]

Time Estimate: 45-60 minutes

Sample lead-in:

Scientists and engineers use the scientific method on a daily basis. Does anyone know what an engineer does?... Engineers are like scientists, because they observe nature, but they use what they learn to design tools that help solve problems. For example, imagine you're an engineer who observes this problem: there's land on two opposite sides of a river and no easy way for people to get across. What tool might you design to solve the problem? How about a ferry boat? How about a bridge? You are now all going to become engineers and solve a very big, very real problem—one that has concerned NASA for some time!

- Students work in engineering teams of four. Give each team an "Airbags on the Moon: Engineering Brief" handout and ask a student to read aloud the "Background" and "Problem."

- Give each team 7 balloons and a roll of masking tape: "These are the materials you have to build a prototype of a new Airbag Landing System. To keep costs down, we're keeping materials as simple as possible."

- Then hand each team one egg: "And this is your piece of super-sensitive scientific equipment." Encourage groups to examine their "cargo" to be sure it isn't already damaged in any way.

- Give each team one "Airbags on the Moon: Engineer It!" handout and explain that each NASA team needs to systematically complete each of the 7 steps. Allow students 10-15 minutes to complete **Steps 1** and **2**.

- **Step 3:** Student teams briefly present their designs, and design rationales, to the class.

- **Step 4:** Allow students 10-15 minutes to create their prototypes. Circulate around the room, as a roving consultant, lending ideas where requested.

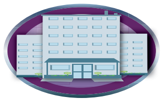
- **Step 5:** "Let's put this to the test. Will your cargo land safely without cracking?" Take students outside and have them drop their airbags—and eggs—from various heights. (They can stand on steps, etc.) In one location, place sharp rocks underneath to simulate inhospitable lunar terrain.

Option: Take pictures of teams, their inventions, and the outdoor experiments.

- **Steps 6 and 7:** Student teams debrief and discuss the results of their experiment. They then share their findings with the class.

Sample wrap-up. Change wording as needed to suit your age group of students:

Whatever work you choose to do when you grow up—whether or not you're an engineer—it will really pay to be able to think like an engineer who's good at experimenting and problem solving. Say you become a teacher: you'll need to experiment to figure out how best to engage your students and get them excited about learning. Say you become a doctor: you may also conduct research to figure out the best way to perform a new operation. Say you become a violinist in a major orchestra: you'll experiment to refine your technique and to figure out how to get the best sound out of your instrument. Problem-solving and creative thinking are universal job requirements!



Invention Challenges on the Job

Time Estimate: 30-45 minutes

- Tell students about things in the workplace that could use improvement. If you could create one thing that would make your job easier, what would that be?

- If you hold a panel discussion, ask panelists to fill in these blanks:
  "I wish I had a better way of ____________________ ."
  "My work life would be easier if ____________________ ."
  "I am often inconvenienced by ____________________."
- Assign one employee to each student team. Employees explain their challenge: something they'd like to see invented or changed to improve life on the job. Each team is given one "invention challenge": Can they brainstorm useful, inventive ideas?

Select Resources

Learn more about NASA, airbag technology, and inflatable structures by visiting the NASA Web site (**www.NASA.gov**), and these pages in particular:

www.nasa.gov/vision/universe/roboticexplorers/airbags.htm
mpfwww.jpl.nasa.gov/MPF/mpf/mpfairbags.html

Encourage girls in your class to visit the Engineer Girl! Web site (www.engineergirl.org) sponsored by the National Academy of Engineering.

Airbags on the Moon: Engineering Brief

Background Briefing

Getting scientific equipment to the Moon or Mars safely, without breaking into pieces, is a big challenge for NASA scientists and engineers. They've experimented with several solutions in the past, such as parachutes, but none of these has worked very well.

NASA engineers recently came up with a new idea. After seeing how airbags protect people from impact in cars, they decided to try airbags in missions to Mars and the Moon to cushion the landing of sensitive scientific equipment on rough and rocky terrain.

The Problem

You are part of a team of NASA engineers who have been asked to design and create a prototype (small model) of an airbag landing system for future Moon voyages. Your challenge: In your team, come up with an airbag system to protect a sensitive and valuable piece of scientific equipment.

Dear Parents and Guardians,

In conjunction with **Take Our Daughters And Sons To Work® Day,** our class has been discussing the scientific method and putting it into practice through prediction and experimentation: "If I do this, I *think* this is what's going to happen… " I encourage you to extend this lesson and continue this discussion at home.

Here are some sample questions/topics for you to discuss with your child:

1. Help your child experiment and put the scientific method into practice in his or her daily life.

Examples: What do you think might be a better way to dribble a soccer ball? To keep your sandwich from getting soggy? To sleep in for 10 extra minutes and still get to school on time?

2. Ask for your child's input on ways to way to improve something at home or at work.

For instance: "I wish I had a better way of ____________." "My work life would be easier if _______________."

Thank you for your interest and participation.

Best,

Airbags on the Moon: Engineer It!

Brainstorm Designs

Brainstorm lots of design ideas for your Airbag Landing System. Remember: in a brainstorm, any idea goes. Sketch ideas here (use another page if needed):

Choose and Predict

Argue for and against each design. Then pick one: Which do you think will work best and why?

____

____

Invention name:________________________________

Present

Present your team's airbag design to the class and explain why you think it will work.

Create

Work together to build a model of your airbag landing system. If you run into any problems, don't hesitate to go back to the drawing board and revise your design.

Test Your Invention

Launch your airbag from different heights and observe what happens. Write down the results of each experiment. Perform at least 3 trials: if the first succeeds, you need to be sure this isn't a fluke!

Improve

What can you learn from this experiment? Have a team discussion and answer 5 questions:

1) How well did our team work together? ❒ Very well ❒ Well ❒ Not very well
2) How would you rate your team's product? ❒ Very Good ❒ Good ❒ Not very good
3) What do you think was the best part of your design, and why?____________________

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____

4) What do you think was the weakest part of your design, and why? ____________________

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5) How could your team make your airbag system better? What difference do you think this change would make?
Draw a sketch of your improved design in the box below.

Share Findings

Tell other design teams what went right, what went wrong, and what you learned. Listen carefully and see what you can learn from other teams' experiences.

[1] This activity was developed with Henry Robinson, Program Manager for Education Programs, The Museum of Science, Boston, MA.

[2] This activity was developed by the Christa Corrigan McAuliffe Center for Education and Teaching Excellence at Framingham State College, Framingham, MA.