discover TECH

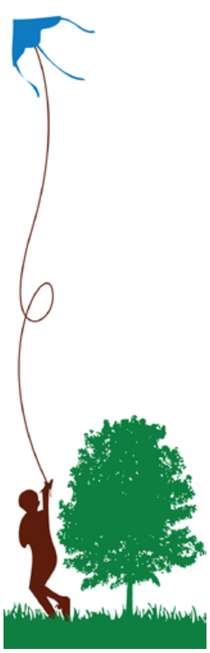
Hands-on Engineering Activities

STAR net

Science-Technology Activities & Resources For Libraries

Implementation Guide

Contents



Credits and Acknowledgements

The *Playful Building* module is a product of the *STAR Library Education Network* project (*STAR_Net*), a national program to support libraries that provide — or want to provide — science, technology, engineering, and mathematics (STEM) informal learning experiences. *STAR_Net* is led by the National Center for Interactive Learning (NCIL) at the Space Science Institute. The project team also includes the American Library Association (ALA), Lunar and Planetary Institute (LPI), and National Girls Collaborative Project (NGCP).

This material is based upon work supported by the National Science Foundation under Grant No. DRL-1010844. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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The *Playful Building* module was developed for libraries to use in support of the *STAR_Net* project's *Discover Tech* traveling exhibit, although it may be implemented independently.

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National Girls Collaborative Project

Playful Building's Key Features

Engineers work to solve the basic challenges of life — including having fun! *Playful Building* explores the process of solving such challenges through engineering in an imaginative task: designing, building, and maintaining a community park! The *Playful Building* activities are designed to engage children, tweens, and families (or other groups of mixed ages) in hands-on engineering fun at the library and other out-of-classroom environments. Young "engineers":

- Plan their dream community park;
- Design and build simple machines used in play; and
- Explore approaches for protecting park visitors from water-borne illness through simple water filtration and for powering the park with wind energy.

Use this implementation guide to plan your approach to any and all of the *Playful Building* activities, which are described in separate documents. All *Playful Building* materials are available free for educational use at www.starnetlibraries.org.

Play

Participants explore how different types of simple machines can be used for fun at a community park. They are challenged to create a simple human machine that transports a bean bag. Many groups solve the challenge with a slide — an inclined plane or an inclined plane that has been twisted into a screw shape — made of their hands. They plan, design, test, and revise a boat (with a bow that serves as a wedge, cutting through water) and update that playground classic, the seesaw (a type of lever).

Activity 2: *Team Machine*
Activity 3: *Water Wedges*
Activity 4: *Levers at Play*

Plan

Participants are invited to imagine the park of their dreams! In small groups, they place moveable pieces on a grid, iterating on their plan together to create a plan for a community park.

Activity 1: *Design a Park*

Implementation Guide

Power and Protect

Families or groups of children are challenged to solve two problems that they might face in a community park: providing clean water and supplying electricity (such as for lighting along paths and trails). They explore and test common materials to identify the best low-tech materials that can be used to help filter water for a pond, water playground, pool, or other recreational water feature. In another activity, explore and test common materials to modify model wind turbines to better catch the wind.

Activity 5: *Low-Tech Water Filter for High-Impact Clean*
Activity 6: *Wind Turbine Tech Challenge*

Thematic

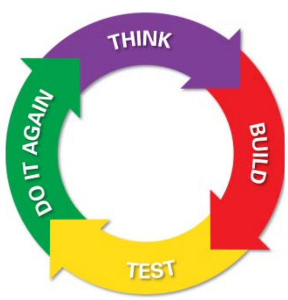
The central idea of a community park provides personal relevance to three key engineering messages:

Engineers work to solve the basic challenges of life — including having fun!

Credit: U.S. Navy/Mass Communication Specialist 2nd Class Gina Wollman

Engineers use technology — including everyday materials — to help us enjoy our world.

Credit: Engineers without Borders



Children, like engineers, can build things using a creative process of thinking, building, testing…and doing it again!

Inexpensive and Flexible

The activities are designed to be easy to implement — use them in family events, after-school programs, summer programs, festivals, engineering days . . . They require readily available — and generally inexpensive — materials. The activities are designed to be expandable and adaptable to a variety of lengths of time and available materials. Select one activity or conduct the entire module! Additional engineering activities are listed as possible extensions, and many of the books listed in the resources section offer even more!

Consider taking the *Playful Building* module to the next level: Encourage teens and adults to build all or part of the components of the community park! The *Levers at Play, Water Wedges,* and *Team Machine* activities introduce some basic experience relating to simple machines, and a natural outgrowth could be to build and install playground equipment at an existing park. *Design a Park* opens the discussion for organizing a community effort to plan, design, fund, and build a community park.

Opportunities for Partnership

While the activities can be implemented by an individual, there are many opportunities to bring in members of the community as co-facilitators!

- Partner with educators from a local community institution (e.g., National Girls Collaborative Project member, museum staff, 4-H club leader, etc.)
- Collaborate with a school. An elementary-, middle-, or high-school teacher could co-facilitate the activities with you, or offer extra credit for students who participate — or for teens helping to co-facilitate! Provide the teachers with a copy of the correlations to National Science Education Standards listed in this guide.
- Invite science, technology, engineering, and mathematics (STEM) professionals to share personal stories about themselves and their careers, co-facilitate activities with you, and be on hand to answer questions. Or, use a platform such as Skype to host a real-time Q&A between the STEM professional and the audience.
- Recruit community college, undergraduate, or graduate engineering students to serve as facilitators.

Adapting Activities for Your Needs

This module is intended to be flexible! Make it your own!

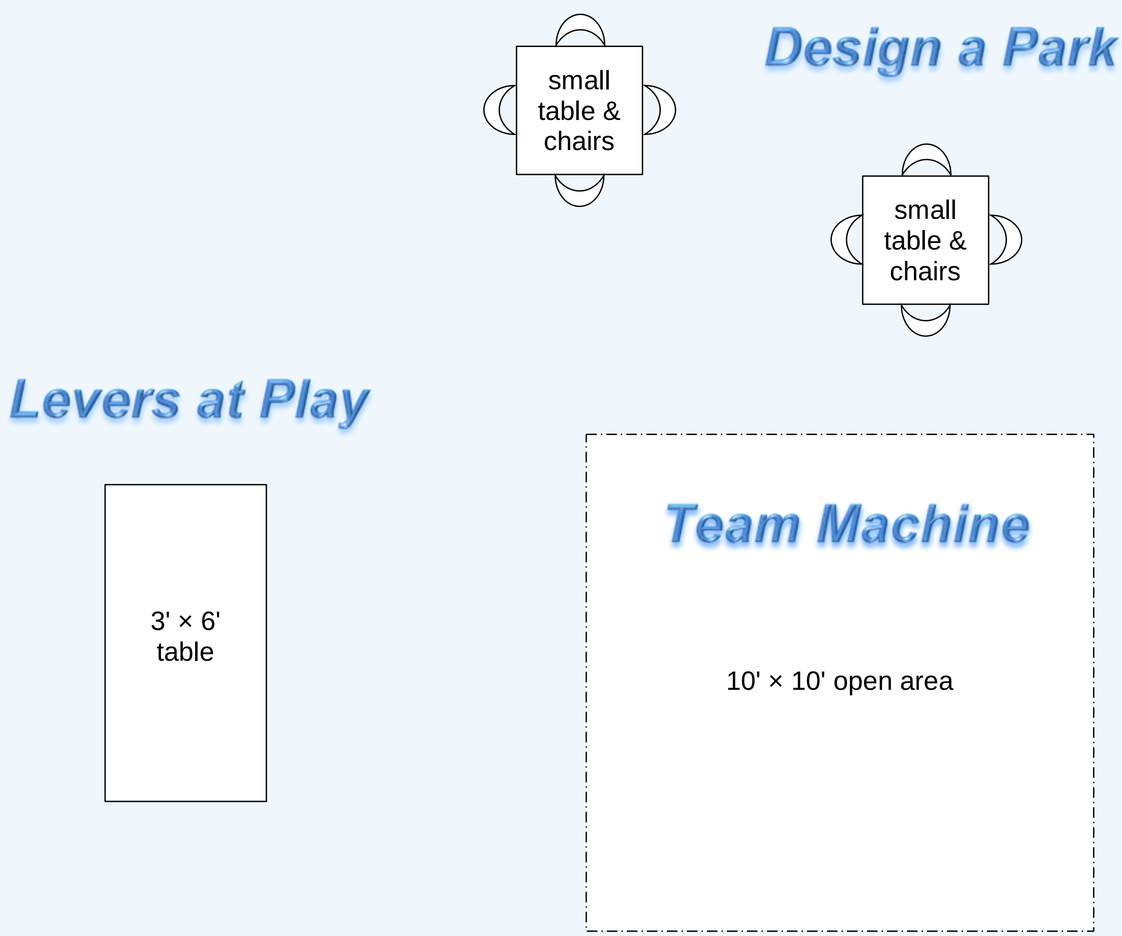
The activities can be facilitator-led and undertaken during separate events. Focusing on a single activity during an event allows participants to spend as much time as they wish iterating on their designs to improve them.

Alternatively, several activities may be offered simultaneously as a series of stations during one or more longer events. Offering several activities alongside each other allows participants to get a taste for multiple engineering concepts in a single event. In addition, the activities can be firmly connected to each other by the context of an imagined community park. However, participants will not have time in the stations format to fully explore the engineering design process. Extra time, space, support staff, or volunteers to host stations, and materials — perhaps as duplicate stations — are necessary.

Tips for Offering Multiple Activities as Stations

- Each activity has step-by-step instructions for the participants as well as a brief facilitation outline that the station hosts can follow.
- Create and post a sign for each area.
- Provide context by first setting the stage with the overarching idea of a community park.
- Plan to allow 20 to 30 minutes for each station. Use a bell, chimes, or cell phone alarm to let the groups know when it is time to rotate.

Sample Room Setup: Playground of Machines



If desired, offer multiple activities during a single event. For instance, Design a Park, Levers at Play, *and* Team Machine *can be offered in conjunction as a “playground of machines.” This diagram illustrates how a room might be divided into three areas for these activities.*

Annotated Facilitation Outline

The following outline can be used to organize your thoughts as you introduce the community park context and key messages about engineering before launching into one or more activities. These points are summarized in the brief facilitation outline that accompanies each activity document.

Introduction

1. Introduce yourself and the library.

Facilitator's Note: If the participants have never been to your library before, use this time to let them know where restrooms and the drinking fountain are and emphasize any safety considerations.

2. Frame the activity(ies) in a way that provides personal relevance (to life, helping others, and having fun) by introducing the main message: Engineers work to solve the basic challenges of life — including having fun!
3. Use open-ended questions (such as those suggested below) to start a conversation about things we need for *enjoyment* in life. Focus on community parks as one example.
    - What do you do to have fun?
    - Where do you go to play?

Facilitator's Note: Open-ended questions are a great way to start an activity! They have no right or wrong answer, so they invite your audience into the conversation — even if they are not very familiar with the topic.

Be sure to allow enough time for participants to respond (try counting silently to yourself for up to a full 15 seconds).

4. Ask additional questions that help the participants think of different ways that engineers help meet many of our needs, both in terms of large-scale systems (infrastructure) and closer to home — at a community park. As needed, draw on the different needs mentioned by the group as examples. Provide details, if necessary, to depict engineering as the following:
    a. Engineers design and support the systems (infrastructure) that support the way we live today:
        - A transportation network allows trucks to bring food and other goods from different areas to our local stores, people to go to work, and freedom of movement;

    - Water systems bring clean water to our houses;
    - Power grids distribute electricity; and
    - Used water, storm water, and garbage are removed.

b. They perform the same kinds of work on a smaller scale to build community parks. They
    - Plan how we will move between areas and build the needed trails or paths;
    - Supply electricity for lights along the trails or bike paths, in the restrooms, and at other buildings like ice cream shops, as well as for powering filters for water features (and heated pools);
    - Provide clean water for water features;
    - Remove used water from restrooms and drinking fountains, redirect storm water, and dispose of trash; and
    - Design structures and controls to maintain healthy wetlands, streams, and ponds.

c. Even simple technologies have the power to improve lives.
    - Engineers are using common materials — such as cloth or systems built from rocks and reeds — as water filters to help prevent diseases in underdeveloped countries.
    - Wind turbines convert renewable wind energy into electricity.
    - Simple machines, like inclined planes, screws, wedges, and levers, have been used for centuries and continue to be central to engineering — and for play!

Facilitator's Note: Covering this information as a conversation rather than as a traditional classroom- or lecture-style presentation:

- Invites participants to be fully engaged in the activity — and motivates them to do so!;
- Gives credit to the participants' own ways of thinking;
- Helps participants recall their own knowledge and experiences; and
- Puts the facilitator in the role of "guide on the side" rather than "sage on the stage."

d. Engineering is a social endeavor.
    - Engineers often work in teams, with different people contributing in different ways, to take on a challenge.
    - Engineers build on the ideas of others.

e. Encourage persistence by noting that successful engineering involves a process of thinking, building, testing . . . and doing it again!
    - Engineers are creative problem-solvers, and they begin by thinking about how others have addressed the problem.
    - Engineers try their initial ideas out, then make a plan based on their best idea and try it out.

- Engineers change their designs, often repeatedly, to arrive at a working solution.

Activity(ies)

Facilitator's Note: Professional engineers find that a thoughtful approach is the key to success! Throughout the activity, help participants become more aware of their own thinking — and create more successful designs — with prompts like the following:

Think:

- Is there something you have seen or experienced in a park or open space that made you happy? Can that help you plan your design?
- As you start thinking about your design, are you first testing how the different things fit together before building it? Are you changing anything out?

Build and Test:

- What would make your attempts easier?

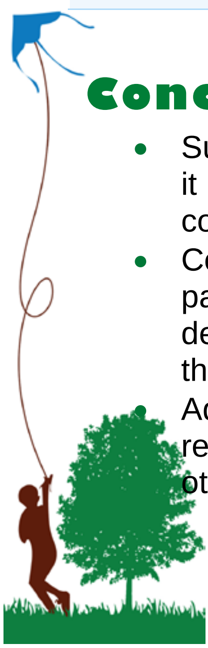
Try it again!

- What do you like about your design?
- What would you add to it?
- Did you continue to rearrange or modify your design as you went along?
- What would you change if you worked on the design longer?
- Could you feel more confident with your design if you shared it with others?

The groups may find it helpful to draw and write their ideas as they are designing — and iterating on that design — during the *Playful Building* activities. By providing a public writing surface, the groups can get ideas from each other. Ideally, seeing others' ideas will foster creativity — much as it does for professional engineers. However, if you find that the groups are merely copying what others have done, provide individual sheets of paper instead.

Conclusion

- Summarize the groups' explorations of the work that engineers do, especially as it relates to the example of designing, building, and maintaining a community park.
- Congratulate the groups on their accomplishments during the activity(ies). In particular, praise groups that encountered failure and persisted by modifying their design. Note how it was important to try again and again in order to test or refine their ideas.
- Advertise any future engineering and technology events: Invite the groups to return to explore the design and creation of an imagined community park through other *Playful Building* activities!

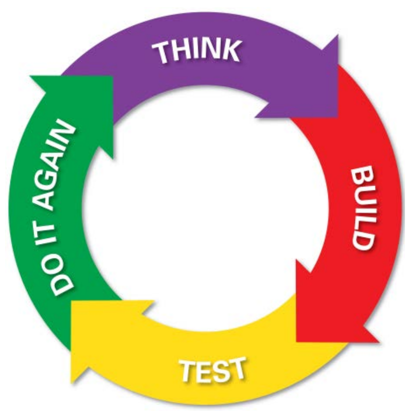


Facilitator Background Information

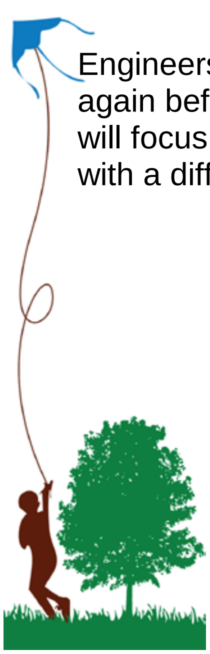
Have you ever ridden a roller coaster? Known someone who had an artificial leg? Gazed up at a skyscraper? They're all examples of how engineers work to solve the basic challenges of life — including having fun!

Engineers ask questions, tinker, and create new technologies. Engineers solve problems that improve lives, like how to get clean water to rural communities. They help humanity face the known and unknown needs of our communities and the planet — using the finite resources available. And they solve problems that make life more fun, like planning, designing, and building community parks.

Engineers tackle challenges through a methodical process: think, build, test . . . and do it again! While engineers don't have official rules telling them to follow this set of steps, this cycle outlines the process that allows engineers to get the best results: Engineers **think** and brainstorm about a problem and factors they have to consider to solve it. They come up with an idea and **build** a prototype. They **test** the prototype. Then they **repeat** the process to improve their results.



Engineers often move back and forth within the loop, repeating two steps over and over again before moving forward. It's a key to engineering success. Sometimes, engineers will focus on one specific step, and when complete, pass the project off to another team with a different skill set.



Low-Tech, High-Impact Technology and Engineering

Engineering doesn't just mean fancy computers and high-tech laboratories. Some projects, like space exploration, require cutting-edge engineering. But, engineering utilizing low-tech materials and techniques has been around for millennia and continues to offer promise for some of the world's serious problems. In developed areas, engineers and scientists are challenged to provide innovative solutions to infrastructure to meet the needs of the population. In underdeveloped areas, they are challenged to improve facilities for growing populations, to improve health, and sustain and improve the quality of life. Innovative engineering solutions will make use of local materials and craftsman.

Some of the simplest machines have been used for centuries and continue to be useful — for work and play!

Playground Machines

Thinkers in ancient Greece and during the Renaissance explored and categorized many of the mechanical devices used to make tools and more complex machines. These "simple machines" remain central to engineering and several types are found in community parks — and elsewhere in our daily lives: inclined planes, screws, wedges, and levers.

Inclined Planes and Screws

An object can be lifted straight up — or it can be pushed diagonally up an inclined plane (like a ramp). Inclined planes make it easier to move something up or down. It takes a stronger pull to lift something up directly than to pull (or push) it up a ramp. It takes the same amount of energy, either way (ignoring friction). But, it takes a smaller pull or push to move that object because it is being pushed it over a longer distance compared to lifting it straight up.

We often encounter inclined planes as we get around in our daily lives: highway access ramps, sidewalk ramps, stairs, as well as switchback roads or trails. Children often use them not to move objects up, but to bring themselves *down*! Slides and skateboard ramps are examples of inclined planes being used for fun.

Spiral-shaped (or "twisty") slides are also common at the playground, and these are examples of screws. A screw is an inclined plane that has been wrapped around a cylinder. (In the case of a spiral-shaped slide at the park, the cylinder may be a pole, or it may be empty space. In the case of screws and bolts, an inclined plane is wrapped around a cylinder of metal.)

Other common screws — screws and bolts — are used to hold two or more materials together. Their threads grip the materials like teeth. They may be holding the playground equipment and picnic tables together!

Wedge

A wedge is a simple machine that pushes materials apart. Wedges have a big (wide) end and a small (narrow) end. Pushing on the bigger end causes an even bigger push (force) on the smaller end in front, pushing the material apart.

For example, consider the bow of a boat being propelled through water. The force of the propeller is transferred to the bow, where it is a larger force because the bow is smaller. The bow passes that force on to the water it touches — as two forces pushing away, perpendicular to the sides of the bow. Those forces push the water apart, allowing the boat to move forward more easily.

Credit: Lunar and Planetary Institute

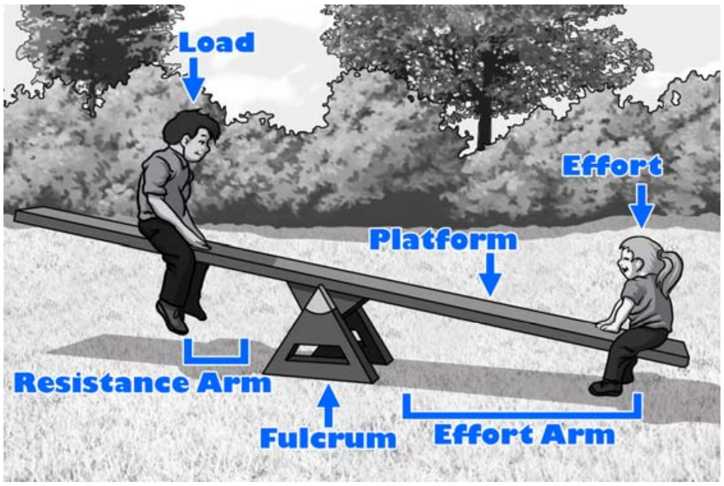
Other wedges play important roles in our daily lives. They are commonly used to build our homes and other buildings — and maintain them, including nails, axes, and saws. Wedges are also important for eating. Our incisor teeth are wedges, as are forks (when used for cutting along the edge) and knives. Wedges can also cut through other materials: The wedge-shaped noses of airplanes cut through the air as they fly.

Lever

A lever is a simple machine that turns a small push or pull (a small force) into a larger (or stronger) push or pull (a larger force). A seesaw is a type of lever.

A lever is made up of a platform, which is turned around a support (i.e., a fulcrum) — or other pivot point. An object resting on the platform is easier to lift. In the case of a seesaw, the platform tips back and forth on a “fulcrum.” A child riding the seesaw applies effort to lift a larger person (say, a parent) who is riding on the opposite end. The child’s side of the lever is the “effort arm.” The adult being lifted is referred to as the “load.” The load rests on the “resistance arm.”

Both weight and distance influence how well the lever works. A single weight can lift a fairly heavy object or several weights — as long as the heavier object is near the fulcrum. Hence, the adult in this illustration sits nearer to the fulcrum. The child's smaller weight is transformed, via this simple machine, into a force that lifts the heavier adult — giving both a fun ride at their community park!



Credit: Lunar and Planetary Institute

Levers are common in our daily lives. Scissors, bottle openers, and fishing poles are all examples of levers. We also build our homes and other buildings — and maintain them — using wheelbarrows, the "claw ends" of hammers, and the arms of mechanical cranes.

Grand Challenges for Engineering

The wheel was once an engineering marvel. But when ancient engineers perfected it, they moved on to the next problem. There's always another challenge — and always another engineering solution to resolve it.

To help engineers focus on our planet's most pressing engineering and technology issues, the National Academy of Engineering developed The Grand Challenges For Engineering. As today's engineers tackle these 14 initiatives related to health, security, sustainability, and the joy of living, they will improve life on Earth and help people thrive.

Two of these Grand Challenges are explored in *Playful Building* through the kid-friendly context of planning, designing, and building model components for a community park:

- Provide access to clean water: Engineers of the 21st century must work to supply water to areas that need it and develop technologies for cleaning water for human use.

- Restore and improve urban infrastructure: Engineers of the 21st century must work to improve the systems that support our communities (such as transportation and energy, water, and waste systems). These systems must also use energy wisely and be better for the environment.

Learn more about these and the other 12 challenges at engineeringchallenges.org.

Clean Water for Everyone

If we want a glass of water, we can turn on the tap. Yet one in six people on Earth do not have reliable access to clean water. Each year millions get sick from dirty water teeming with pathogens. Engineers have transformed life for thousands with inexpensive filters built from local materials like concrete and pebbles. Sometimes a low-tech solution is better and cheaper than a high-tech one could ever be.

Simple filters can be very effective for removing contaminants. For instance, Dr. Rita Colwell, former director of the National Science Foundation (NSF), helped people in Bangladesh clean their water — with their clothes! Sari cloth is layered on top of a water jar. The cloth catches most of the microscopic plants and animals — plankton — that live in the water. The bacteria that cause the disease cholera cling to the surface of the plankton. Filtering out the plankton also removes most of the harmful bacteria!

A microscope allows us to see this very small creature — a copapod — that lives in the water. Disease-causing bacteria cling to these creatures, helping disease to spread.

Credit: National Science Foundation.

Students Changing the World
Engineers Without Borders (EWB) improves the lives of people in developing countries through engineering. They tap the ingenuity of university students and professional engineers to address health and safety issues. Their projects include building water filtration and irrigation systems as well as engineering roads and dams.

EWB is helping a community in Nepal clean their water. Run-off from a hospital has been contaminating springs downstream from it. Undergraduate engineering students installed a low tech-solution using local materials and ideas that are already familiar to the indigenous people. They used rocks and reeds, and created an environment where helpful bacteria would grow, to clean the water as it leaves the hospital.

Credit: Engineers without Borders

Closer to home, low-tech solutions play an important role in larger systems to keep our water clean. Water features like ponds, fountains, water playgrounds (or "spraygrounds"), and pools are fun ways to enjoy water at community parks. Over time, the water becomes dirty: Dirt and leaves from trees and plants will blow into the water. Algae and bacteria may grow in the water. Chemicals — like pesticides — may run off into the water during rainstorms. These contaminants must be removed as part of the maintenance of the park in order to protect people from getting sick.

Wetlands are nature's water filters. Water tends to slow down when it enters a wetland. Like in a snow globe, particles settle out of the water when it becomes more still. The particles can include sediment, chemicals, and excess nutrients (which could otherwise lead to algae blooms in lakes or oceans downstream).Wetland plants and microbes take up or begin to degrade chemicals.

Credit: Lunar and Planetary Institute

To clean water for human use — including swimming pools and drinking water — water is treated beyond filtration. Chlorine is generally used to help prevent the spread of disease in swimming pools. Water may also be heated or exposed to ultraviolet radiation to disinfect it. Drinking water, processed by city municipalities, is cleaned through multiple steps.

The Challenge of Supplying Our Urban Infrastructure with Electricity

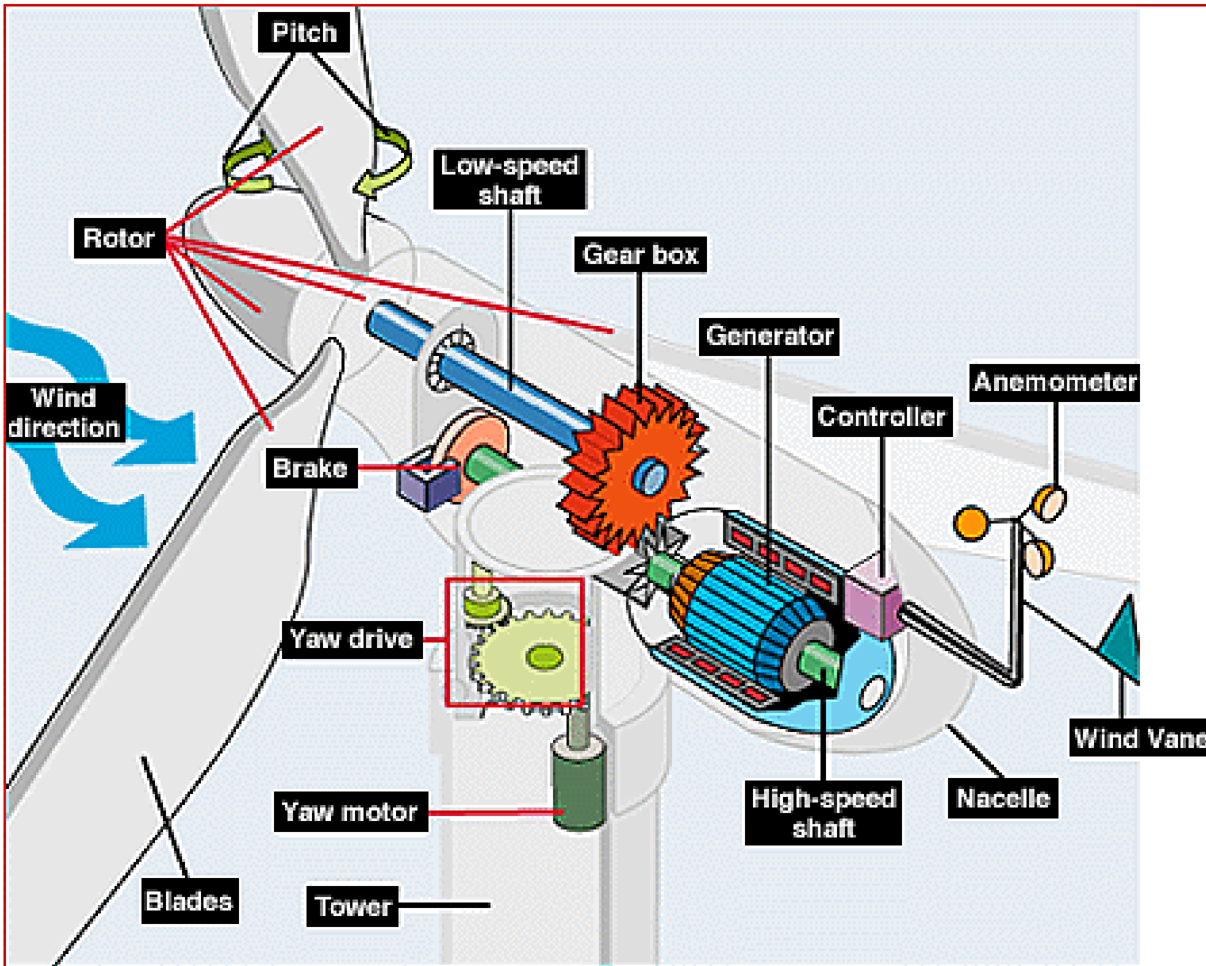
Most of Earth's energy comes from the Sun. The Sun's energy warms our planet, helps plants grow, and makes the wind blow. Even fossil fuels are the Sun's energy stored in ancient plants from millions of years ago. Engineers harvest this energy to provide us with electricity.

Credit: Ivan Prole

Power plants — which generally run on fossil fuels — distribute energy through the power grid, an interstate highway system for electricity. The National Academy of Engineering named this distribution network one of the greatest achievements of the 20th century. But, to function well in a 21st century world, the power grid needs to be updated to accommodate increased use; replace aging parts; and integrate smaller, local sources of renewable power.

The monetary and environmental costs of harvesting fossil fuels have begun to outweigh their benefits, so engineers are turning toward sources of renewable energy, such as wind energy. While wind currently only supplies less than 2% of U.S. energy production, a U.S. Department of Energy (DOE) report found that wind has the potential to supply 20% by 2030. To do so, engineers and scientists must continue to work toward reducing the costs and advancing the technology further.

Wind turbines capture the wind, transforming motion into electricity. Wind blows against the blades of a wind turbine, making the blades spin. The blades are connected to one end of a shaft that rotates with the blades. The other end of the shaft is connected to a gear box. These gears are connected to another shaft and the gears cause this second shaft to rotate faster than the blades and the first shaft. This second, faster shaft is connected to a generator. As the second shaft rotates inside the generator, electricity is produced. More than 8000 parts contribute to the makeup of a modern wind turbine.



Credit: National Renewable Energy Laboratory

The speed and direction the wind primarily blows varies across Earth's surface. Wind turbines are designed to take advantage of wind patterns in the locations at which they are installed. Engineers create physical models of wind turbines and place them in wind tunnels to simulate the wind conditions of a certain locality. Tests are run to understand how different designs will stand up to the conditions created inside the wind tunnel. Engineers use the information from these tests to determine the best way to construct components of wind turbines — the tower height, number of blades, and blade shape, for example.

Meeting the world's energy needs will require more than one solution. In addition to wind energy, engineers are developing technologies and systems for other types of renewable energy:

- Solar engineering is now mainstream and increasingly efficient. In addition to rooftop solar panels, solar technicians now make "solar trackers." These giant mirrors follow the Sun across the sky to capture energy when the Sun is not overhead. Another innovation, a "solar concentrator," focuses the Sun's light — like shining a sunbeam through a magnifying glass — to produce even greater solar output.
- Biofuel turns plants, like corn and sugarcane — even grasses and woodchips — into fuel used in certain automobiles.
- Hydropower harnesses the energy of flowing water to drive turbines to produce electricity.
- As garbage decays, it releases methane. Trash companies capture that gas, chill it until it liquefies, and use liquid methane to power their trucks.
- Geothermal energy captures heat escaping from deep inside Earth. It's most easily used where there are cracks channeling this heat to the surface.

One way to upgrade the power grid is to create many, smaller, regional power grids. If we generate energy closer to where it is used, power can be more efficient, reliable, and secure. Integrating many new power sources is a technological and policy challenge.

Engineering employs all levels of technology, from the simple machines used to build and maintain our homes, to simple materials made into a basic filtration system, to the 8000 parts working in harmony in a turbine to capture the wind and transform it into electricity. Engineers of the 21st century will continue to strive to meet new challenges, including the 14 initiatives that make up the Grand Challenges for Engineering identified by the National Academy of Engineering.

Shopping List

The following is an abbreviated list of the materials required for the *Playful Building* module of activities. Refer to the materials section of each activity for details, such as possible substitutions, suggestions for books and websites, printing recommendations, and other notes. Many of the materials are repurposed items, such as empty, cleaned two-liter bottles; consider gathering donations from your community.

Activity 1: Design a Park

Facility Needs

- ☐ Optional: computer, speakers, projector, projection screen, and access to the Internet
- ☐ 6 or more small tables, each with 4 or more chairs

For Each Family/Small Group of 3–4

- ☐ 1 park map set, which includes:
  - ☐ 1 (27" × 34" or so) blank sheet of graph paper (with 1-inch square rule)
  - ☐ 1 (8½" × 11") set of *Park Features*
  - ☐ 1 (44") length of brown, tan, or gray yarn
  - ☐ 1 pair of safety scissors
  - ☐ 10 yellow pony beads in a small container (such as a cup or baggie)
  - ☐ 1 calculator

For an Audience of 15–20 to Share

- ☐ 1 (8½" × 11") *Be Creative…Be an Engineer!* poster
- ☐ Optional: 1 (8½" × 11") *Grand Challenges of Engineering* poster
- ☐ Optional: coloring supplies

For the Facilitator

- ☐ *Brief Facilitation Outline* page
- ☐ *Playful Building* PowerPoint presentation

Activity 2: Team Machine

Facility Needs

- ☐ A (10' × 10') area where six to eight people can stand, crouch, and sit
- ☐ Optional: 4–6 chairs for those who need to sit to participate in this activity
- ☐ Optional: computer, speakers, projector, projection screen, and access to the Internet

For Each Large Group of 6–20 Participants

- ☐ 1 bean bag (or other small, soft object)
- ☐ 1 stopwatch
- ☐ 1 (8½" × 11") *Be Creative…Be an Engineer!* poster

For the Facilitator

- ☐ *Brief Facilitation Outline* page
- ☐ *Playful Building* PowerPoint presentation

Activity 3: Wet Wedges

Facility Needs

- ☐ Access to water
- ☐ 3 or more tables
- ☐ Optional: 15–20 chairs arranged at the table(s) for groups or families to sit together while they fold paper
- ☐ Optional: computer, speakers, projector, projection screen, and access to the Internet
- ☐ Optional: a writing surface where the groups may sketch and write, such as:
  - ☐ 1 white board

    OR
  - ☐ 2–4 (~36" × 48") pieces of butcher paper, posted on the wall or used to cover the tables

    OR
  - ☐ 5 or more sheets of poster paper

  AND

  - ☐ 4–8 dry-erase or other appropriate low- or no-odor markers

    OR
  - ☐ 4–8 crayons

For Each Family/Small Group of 3–4

- ☐ A choice of materials for making a boat with a bow:
- ☐ 1 (pint- or quart-sized) clean, empty cardboard milk or juice carton (with a "pointed" top)

  AND

  ☐ 1 box cutter for an adult helper to use
- ☐ 2–4 (8.5" × 11") sheets of glossy paper (recycled flyers or small posters work well)
- ☐ A selection of materials for making a boat without a bow, such as
  - ☐ 1 aluminum pie pan
  - ☐ 1 (1' × 1') sheet of aluminum foil
  - ☐ 1 (1' × 1') sheet of bubble wrap
  - ☐ 2 Ziploc® sandwich bags
  - ☐ A variety of clean, empty reused containers:
    - ☐ 1 (8 oz.) water bottle
    - ☐ 1 small Styrofoam container (e.g., a clamshell or cup)
  - ☐ 12–24 drinking straws, all of one color, cut in half
  - ☐ 2–4 (~9" × 12") sheets of plastic wrap
- ☐ Optional: a selection of materials to build sails and/or balloon "motors":
  - ☐ 1 sheet of construction paper
  - ☐ 1 (4" or 6" square) piece of fabric
  - ☐ 1 skewer, dowel, or other stick
  - ☐ 1 balloon
  - ☐ 1 clean, reused plastic grocery bag

For an Audience of 15–20 to Share

- ☐ 3 (9" × 13" or larger) pans or plastic tubs each filled with water to at least about 2" deep

  OR

  ☐ 1 wading pool filled with water to at least about 2" deep
- ☐ 6 pairs of safety scissors
- ☐ 6 rolls of Scotch tape
- ☐ 6 rolls of masking tape

- ☐ 6 rolls of packing tape
- ☐ 6 rolls of duct tape (in fun colors, if possible)
- ☐ 6 rolls of string
- ☐ 6 staplers (for a teen or adult helper to use)
- ☐ 1 roll of paper towels
- ☐ Optional: 6 (4- or 6-oz.) containers of Play-Doh (for holding parts in place)
- ☐ 1 (8½" ×11") *Be Creative…Be an Engineer!* poster

For the Facilitator

- ☐ Supplies for preparing empty, reused containers:
- ☐ 1 pair of rubber gloves (and any other desired safety gear)
- ☐ 1 (1-gallon) bucket or bowl filled with very warm water
- ☐ 1 tablespoon bleach
- ☐ Scissors
- ☐ Optional: 1 jar of blue or green glitter
- ☐ Optional: 1 (~6"-wide) stainless steel strainer with a fine mesh
- ☐ *Brief Facilitation Outline* page
- ☐ *Playful Building* PowerPoint presentation

Activity 4: Levers at Play

Facility Needs

- ☐ 3 or more tables
- ☐ Optional: 15–20 chairs arranged at the table(s) for groups or families to sit together while they create their boats
- ☐ Optional: a writing surface where the groups may sketch and write, such as
  - ☐ 1 white board

    OR
  - ☐ 2-4 (~36" × 48") pieces of butcher paper

    OR
  - ☐ 5 or more sheets of poster paper

  AND
  - ☐ 4–8 dry-erase or other appropriate low- or no-odor markers

    OR
  - ☐ 4–8 crayons
- ☐ Optional: computer, speakers, projector, projection screen, and access to the Internet

For Each Family/Small Group of 3–4

- ☐ 10 small, relatively heavy objects, such as:
  - ☐ Weights
  - ☐ Pennies
  - ☐ Metal washers
  - ☐ Small rocks
  - ☐ Dried beans
  - ☐ Optional: 2–3 LEGO® people
- ☐ A selection of long, thin, flat boards, such as:
  - ☐ Rulers
  - ☐ Paint stirrers
  - ☐ Popsicle sticks
  - ☐ Large craft sticks

- ☐ Yardsticks
- ☐ A selection of objects to serve as fulcrums, such as:
  - ☐ Soup cans (tape the edges on clean, repurposed cans)
  - ☐ Paper-towel tubes
  - ☐ Dowels
  - ☐ Ribbon and thread spools
  - ☐ Markers
  - ☐ Pencils
  - ☐ Triangular blocks
- ☐ 2 small paper cups (such as 3-oz. Dixie® bath cups)
- ☐ Optional: 3 adhesive labels (pre-printed with the terms “load,” “fulcrum,” and “effort”)
- ☐ Optional: broom or long, flat board AND ☐ Bean bag chair or other fairly heavy object

For an Audience of 15–20 to Share

- ☐ 1 (8½" × 11") *Be Creative…Be an Engineer!* poster
- ☐ A selection of adhesives:
  - ☐ 3 or more rolls of masking tape
  - ☐ 3 packages of putty adhesive, such as Sticky Tack
  - ☐ 1 (1/2" size, 200 ct.) roll of Glue Dots®

For the Facilitator

- ☐ *Brief Facilitation Outline* page
- ☐ *Playful Building* PowerPoint presentation

Activity 5: Low-Tech Water Filter for High-Impact Clean

Facility Needs

- ☐ Access to water for cleaning containers during the activity
- ☐ Access to 3–4 rolls of paper towels
- ☐ Access to one or more trash receptacles
- ☐ 1–2 tables, covered in disposable table cloths
- ☐ Optional: computer, speakers, projector, projection screen, and access to the Internet
- ☐ Optional: a writing surface where the groups may sketch and write, such as:
  - ☐ 1 white board
  - OR
  - ☐ 2-4 (~36" × 48") pieces of butcher paper
  - OR
  - ☐ 5 or more sheets of poster paper

  AND

  - ☐ 4–8 dry-erase or other appropriate low- or no-odor markers
  - OR
  - ☐ 4–8 crayons
- ☐ Access to an outdoor area to dry and reuse or dump several types of garden-safe materials after the activity

For an Audience of 15–20 to Share

- ☐ 5–6 (2-L) empty, *clear plastic* water bottles
- ☐ 1 (16-ounce or larger) clear plastic container
- ☐ 1–2 (36" × 3 yards) packages of cheesecloth
- ☐ 10 rubber bands

- ☐ 10 or more (~10" × 5") pieces of silk and/or cotton knit fabric
- ☐ 6 cups of play sand
- ☐ 5 cups of *small* aquarium gravel
- ☐ 10 (~1-inch) chunks of lava rock
- ☐ 4 cups activated carbon/charcoal
- ☐ A selection of additional filtration materials to choose from, such as:
    - ☐ 1 cup of rice
    - ☐ 30 (5/8") marbles
    - ☐ 30 (non-biodegradable/dissolvable) Styrofoam peanuts or "popcorn"
    - ☐ 10 (1" × 1") pieces of synthetic sponge
    - ☐ 1 package of cotton balls
    - ☐ 10 (5" × 5") pieces of quilt batting
    - ☐ 2 cups paper, shredded into strips or torn into ~½" pieces
    - ☐ 10 coffee filters
- ☐ 1 batch of "dirty water" created with:
    - ☐ ~2 teaspoons of tea leaves (or the contents of 3–4 tea bags)
    - ☐ 3 cups boiling hot water
    - ☐ 1 (1-quart) tea pot or Pyrex measuring cup
    - ☐ 2 or more (~1-cup) containers for holding and pouring "dirty water," such as measuring cups (preferably with spouts for easy pouring) or clean, empty personal water bottles AND ☐ 2 or more labels or pieces of masking tape
- ☐ 6 teaspoons or medicine droppers (for adding "dirty water" to the filters in small amounts)
- ☐ 6 empty jars, pitchers, or other containers for collecting filtered water for later disposal
- ☐ Optional: microscope, microscope slides, and water samples collected from a park fountain, stream, pond, or lake
- ☐ 15–20 aprons or trash bags to wear over clothing
- ☐ Safety signs, which read "Be safe! Do not drink this water"
- ☐ 1 (8½" × 11") *Be Creative…Be an Engineer!* poster
- ☐ Optional: 1 (8½" × 11") *Grand Challenges of Engineering* poster

For the Facilitator

- ☐ Scissors
- ☐ 1 fine-tipped permanent marker
- ☐ 1 ruler
- ☐ *Brief Facilitation Outline* page
- ☐ *Playful Building* PowerPoint presentation

Activity 6: Wind Turbine Tech Challenge

Facility Needs

- ☐ 3 or more or more tables
- ☐ Optional: 15–20 chairs arranged at the table(s) for groups or families to sit together while they create their wind turbines
- ☐ Optional: computer, speakers, projector, projection screen, and access to the Internet
- ☐ Optional: a writing surface where the groups may sketch and write, such as:

- ☐ 1 white board

  OR

- ☐ 2-4 (~36" × 48") pieces of butcher paper

  OR

- ☐ 5 or more sheets of poster paper

AND

- ☐ 4–8 dry-erase or other appropriate low- or no-odor markers

  OR

- ☐ 4–8 crayons

For Each Participant

- ☐ 2 drinking straws
- ☐ 4 (3" × 3") small Post-It Notes®
- ☐ 3–4 round toothpicks
- ☐ 1 small (approximately 1" × 1") scrap of paper (preferably left over, repurposed paper)
- ☐ 1 (1"-diameter) chunk of Play-Doh or putty adhesive, such as Sticky Tack
- ☐ Materials from which to choose to modify his or her model wind turbine:
  - ☐ 1 paper towel tube
  - ☐ 4 (3" × 3") pieces of thin cardboard (for example, from a cereal box or folder), index cards, or cardstock
  - ☐ 4 (3" × 3") pieces of corrugated cardboard
  - ☐ 2 (8½" × 11") sheets of printing paper (can be used for blades or vertical support)
  - ☐ 2 sheets of tissue paper
  - ☐ 2 sheets of construction paper

For an Audience of 15–20 to Share

- ☐ 6 or more rolls of Scotch tape
- ☐ 6 or more glue sticks
- ☐ 3 or more boxes of brass brads
- ☐ 1 (8½" × 11") copies of the *Be Creative…Be an Engineer!* poster
- ☐ Optional: 1 (8½" × 11") *Grand Challenges of Engineering* poster

For the Facilitator

- ☐ *Brief Facilitation Outline* page
- ☐ *Playful Building* PowerPoint presentation

Extended Supporting Media Suggestions

Related books

Engineering Solutions

Hop! Plop!
Corey Rosen Schwartz and Tali Klein, Walker Childrens, 2006, ISBN: 9780802780560
Friends Elephant and Mouse visit a playground and struggle to use the playground equipment. For example, Mouse is sent flying when Elephant sits opposite him on the seesaw. Appropriate for ages 3 and up.

On the Seesaw Bridge
Yuichi Kimura, Vertical, Vertical, 2011, ISBN: 9781935654186
A fox and his potential prey, a hare, are trapped on a seesaw bridge. They use the bridge's movement to launch themselves to safety. Appropriate for ages 4 and up.

How Do You Lift a Lion?
Robert E. Wells, Albert Whitman & Company, 1999, ISBN-13 9780780779228
Children ages 4–8 can imagine how levers, wheels, and pulleys could be used to move heavy animals in this playful exploration of simple machines.

Making Water Clean
Rebecca Olien, Capstone Press, 2006, ISBN 9780736851787
The photographs and clear text in this book explore water as rain, in lakes and rivers, and from the tap. Appropriate for ages 6–9.

Clean Water (Sally Ride Science)
Beth Geiger, Flash Point, 2009, ISBN 9781596435773
Photographs, illustrations, and examples from countries throughout the world are used to highlight some developing technologies for recycling and desalinating water. Appropriate for ages 8–12.

Build Your Own Fort, Igloo, and Other Hangouts
Tammy Enz, Capstone Press, 2011, ISBN 9781429654364
Enz provides step-by-step instructions for building outdoor hang-outs from a variety of found materials, including empty soda can boxes, bed sheets, or snow. Appropriate for ages 8–14.

Build Your Own Periscope, Flashlight, and Other Useful Stuff
Tammy Enz, Capstone Press, 2011, ISBN 9781429654395
Enz provides step-by-step instructions for building projects, such as a telephone talker and homemade flashlight. Some steps require adult assistance. Appropriate for ages 8–14.

Bridges! : Amazing Structures to Design, Build & Test
Carol A. Johnmann, Elizabeth J , Rieth, and Michael P. Kline, Williamson Publishing Company, 1999, ISBN 1885593309
Engaging text and illustrations highlight different bridges, in addition to the teamwork, materials, and basic concepts that go into building them. Appropriate for ages 7 and up.

Cool Engineering Activities for Girls
Heather Schwartz, Capstone Press, 2012, ISBN 9781429676779
Photographs depict girls undertaking nine different projects, including a water filter and solar cooker. Step-by-step instructions are provided. Appropriate for ages 8–14.

Janice VanCleave's Engineering for Every Kid: Easy Activities That Make Learning Science Fun
Janice VanCleave, Jossey-Bass, 2007, ISBN 9780471471820
VanCleave provides background information, exercises, and hands-on activities for each of 25 different engineering topics. Topics include Push and Pull: Structural Engineering, Coming Through: Solar Engineering, and Around and Around: Hydrology Engineering. Appropriate for ages 8–12.

Easy Origami
Dokhohtei Nakano (translated by Eric Kenneway), Puffin, 1994, ISBN-13: 978-0140365252
This book provides folding instructions for a variety of objects. Appropriate for ages 9 and up.

Origami
Hideaki Sakata, Japan Publications Trading, 1984, ISBN-13: 978-0870405808
Note: This book is out of print, but is recommended if available. Its colorful photographs and simple directions are excellent to guide beginners through a variety of folding projects. Appropriate for ages 9 and up.

Rocket Science: 50 Flying, Floating, Flipping, Spinning Gadgets Kids Create Themselves
John Wiese, John Wiley & Sons, 1995, ISBN 9780471113577
Children can create myriad working toys, such as boats, rockets, a doorbell, a variety of musical instruments, and more! Wiese provides instructions for the children, and when necessary, their adult helpers. The book provides an avenue for exploring many of the *Playful Building* activities, including more fun with levers, boats, and windmills. Appropriate for ages 9 and up.

The Art of Construction: Projects and Principles for Beginning Engineers & Architects
Mario Salvadori, Chicago Review Press, 2000, ISBN 9781556520808
Children explore structures through engaging, clear text and projects. Appropriate for ages 9 and up.

Physics, Fun, and Beyond: Electrifying Projects and Inventions from Recycled and Low-Cost Materials
Eduardo de Campos Valadares, Prentice hall, 2005, ISBN 9780131856738
This book details a multitude of projects with step-by-step instructions and explanations of the physics behind the fun. Some projects require easily acquired materials, but tools are necessary for others (and require adult assistance or supervision). Appropriate for ages 10 and up.

Engineering the City: How Infrastructure Works
Matthys Levy and Richard Panchyk, Chicago Review Press, 2000 ISBN 1556524196
Future engineers, math enthusiasts, and students seeking ideas for science projects will all be fascinated by this book, which is filled with engineering “projects and principles for beginners.” Facts about dams and bridges segue into information about water transportation and irrigation, and eventually into a chapter that answers the question, “What happens when I flush the toilet?” Other sections deal with highways, railroads, electrical circuitry, and garbage disposal. Simple line drawings unobtrusively enhance descriptions in the text, and there are specific, step-by-step ideas for engineering experiments that usually require only simple household objects. Appropriate for young adults and adults.

Invention and Innovation

Amazing Leonardo Da Vinci Inventions You Can Build Yourself
Maxine Anderson, Nomad, 2006. ISBN 9780974934426
This unique look into the life and inventions of Leonardo da Vinci also provides step-by-step instructions for replicating some of his creations, such as a monster mask or portable bridge. Appropriate for ages 9–12.

Ancient Machine Technology: From Wheels to Forges
Michael Woods and Mary B. Woods, Twenty-First Century, 2011, ISBN-13 978-0761365235
This book combines engineering and science concepts with information about ancient cultures to explore simple machines. Appropriate for ages 12 and up.

Rocket Boys
Homer Hickam. Delta, 2000 ISBN 0385333218
This bestselling memoir tells the story of the author’s life growing up in a harsh West Virginia mining town, and how he grew up to become a NASA engineer. *Rocket Boys* inspired the film *October Sky.* Appropriate for young adults and adults.

Engineers Are Real People

Engineering the ABC's : How Engineers Shape Our World
Patty O'Brien Novak and Don McLean, Ferne Press, 2010, ISBN 9781933916514
Colorful illustrations, text, and interesting facts discuss the contributions engineers make to a variety of familiar objects, such as cars, quarters, and umbrellas. Appropriate for ages 4–8.

eGFI Kids' Book: If I Were an Engineer
Introduce kids ages 5 to 8 to engineering through rhyme. Available through https://shop.egfi-k12.org.

Changing Our World: True Stories of Women Engineers Book
Sybil E. Hatch, *American Society of Civil Engineers, 2006, ISBN 9780784408414*
This book offers an inspirational look at the important work of women engineers of all ages and backgrounds. Appropriate for ages 12 and up.

Smart Technology (e.g., Clean Energy)

Harness It : Invent New Ways to Harness Energy and Nature
Tammy Enz,, Capstone Press, 2012, ISBN 9781429676335
Enz provides step-by-step instructions for building projects, including a solar cooker. Appropriate for ages 8–11.

The History of Energy
Elaine Landau, Twenty First Century Books, 2005, ISBN 9780822538066
This overview of the history of different energy sources includes a chapter about wind and water. Appropriate for ages 10 and up.

Solar Cell and Renewable Energy Experiments
Edwin Sobey, Enslow, 2011, ISBN 9780766033054
Sobey offers background information and step-by-step instructions for conducting experiments related to electricity, solar power, wind power, and hydropower. Ideas for science fair projects are also provided. Appropriate for ages 11–14.

Related Websites

Engineering Solutions

National Academy of Engineering Grand Challenges for Engineering
www.engineeringchallenges.org
View a list of the Grand Challenges for Engineering as determined by a committee of the National Academy of Engineering, offer your ideas, and learn about potential next steps. Adults may participate in fully moderated online discussions relating to engineering challenges in their communities.

Engineers Without Borders
www.ewb-usa.org
Learn about Engineers Without Borders projects and find ways to get involved in a variety of programs happening around the world.

Engineering.com
www.engineering.com
This site offers articles about current topics relevant to engineers and engineering, videos, an “Ask” forum, games, and puzzles.

Science Daily
www.sciencedaily.com/news/matter_energy/engineering/
Science Daily provides articles about the latest engineering and science news.

Tillery Park
www.tillerypark.org
Tillery Park was renovated in 2007 thanks to community-based efforts. Read about the design stage and the costs and placement of playground equipment in the “playground” tab. Find similar projects through the designer’s website: www.leathersassociates.com.

Invention and Innovation

Engineering Design Process

www.theworks.org/fb/teachers/engineering_design_process.html
The Works — an engineering process page from the The Works, a hands-on museum.

pbskids.org/designsquad/pdf/parentseducators/workshop/designprocess_poster.pdf
Design Squad engineering design process page from the popular and successful PBS show “Design Squad.”

www.mos.org/eie/engineering_design.php
Engineering is Elementary engineering design process page.

www.nasa.gov/audience/foreducators/plantgrowth/reference/index.html
NASA engineering design processes: one for K–4 and one for grades 5–12.

Greatest Engineering Achievements of the 20th Century
www.greatachievements.org
A timeline and background of engineering innovations, from the toaster to the Internet.

National Science Foundation Directorate for Engineering
www.nsf.gov/dir/index.jsp?org=ENG
Includes listings of engineering organizations, programs, articles, funding opportunities, and additional resources.

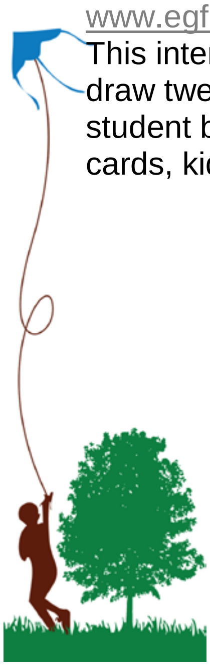
MIT Open Course Ware
ocw.mit.edu/courses
Free online course material from MIT classes (including engineering, physics, etc.), some complete with video.

Engineers Are Real People

Try Engineering
www.tryengineering.org
TryEngineering offers a variety of resources for those seeking a career in engineering as well as those already established in a career. There are also games and resources for children of all ages.

Discover Engineering
www.discoverengineering.org
This website has video activities focused on sustainable energy and solar energy. It also includes career profiles, career facts, news in the engineering world, and a fun “Did you know?” section. Appropriate for ages 11 and up.

eGFI: Dream up the Future
www.egfi-k12.org
This interactive website by the American Society for Engineering Education (ASEE) will draw tweens and teens into its content, including engineering news (delivered via student blog and e-newsletters), “Meet an Engineer” profiles, and facts. A poster, flash cards, kids’ book, and magazine are available for purchase.



Changing the Conversation

www.engineeringmessages.org

Visit the NAE's Changing the Conversation website to learn more about how to talk to young people in ways that will inspire them to pursue engineering and to take on the Grand Challenges. The site includes good examples of engineering outreach, messaging, and taglines that were focus group-tested, and a community of users who share ideas. Intended for adult users.

Engineer Your Life

www.engineeryourlife.org

This guide to engineering offers videos, photos, career stories, and personal “tidbits” for each of 12 engineering professionals. While the content is aimed at high school girls, the site is appropriate for ages 8 and up. Teens might find the additional tools and information helpful for pursuing a career in engineering.

Engineer Girl

www.engineergirl.org

Developed by the National Academy of Engineering (NAE), the EngineerGirl website is a guide to engineering careers for middle-school girls. In addition to browsing information, such as profiles of women engineers and the multitude of ways engineers help people, girls can submit their questions online to engineers and enter the annual EngineerGirl contest. Appropriate for ages 8 and up.

Real Scientists

pbskids.org/dragonflytv/scientists/index.html

View profiles of real scientists and engineers, including an electrical engineer, aeronautical engineer, audio engineer, and more. Appropriate for kids.

Smart Technology (e.g., Clean Energy)

Renewable Energy Engineering

renewableenergyengineering.com

This website provides information, products, services, and more to help anyone interested in experimenting with renewable energy. There are a variety of resources, projects, and resources to help novices and experts.

California Center for Sustainable Energy

energycenter.org

This website has resources and ideas that help residents, businesses, and public agencies save energy, reduce grid demand, and generate their own power through a variety of rebate, technical assistance, and education programs.

Guides to Science and Exhibits in the Library

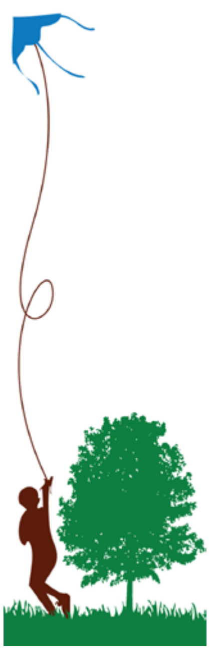
Exploring Science in the Library: Resources and Activities for Young People
Maria Sosa and Tracy Gath (editors), American Library Association, 2000,
ISBN 838907687
This book covers many useful approaches for bringing science to your library. Chapters 6 and 8, "Inquiry-Based Learning in the Library" and "Partnerships to Promote Science Activities in the Library," respectively, are packed tips and even a few fun science activities. Selecting children's science books and fundraising ideas are also covered.

Exhibits in Libraries: A Practical Guide
Mary E. Brown and Rebecca Power, McFarland & Company, Inc., 2006,
ISBN: 78642328
This guide covers the development, set-up, and programming of exhibits in libraries.

Related Periodicals

MAKE Magazine
makezine.com/magazine
This quarterly publication caters to those with a "do-it-yourself" approach to technology at home and elsewhere. It includes projects across a range of difficulty levels.

eGFI — Engineering, Go For It
students.egfi-k12.org/read-the-magazine.htm
Engaging graphics and engaging engineering stories will capture the interest of young people. The magazine is published every two years by the American Society for Engineering Education. Especially appropriate for tweens and teens.



Related Videos and TV Shows

Peep and the Big Wide World
www.peepandthebigwideworld.com
View a weekly selection of videos and find related resources, including games, a blog, and the *PEEP and the Big Wide World* Event Kit — with details for offering a Exploring Structures and Exploring Ramps event — on the website. The show is geared toward preschool-aged children.

SciGirls
pbskids.org/scigirls
This Emmy Award-winning television series is based on best practices for engaging girls in science, technology, engineering, and math (STEM). In each half-hour episode, middle-school-aged girls undertake STEM-themed activities. Girls (and their teachers and parents) can find related resources, including projects, videos, and games, through the kid-friendly website. Appropriate for ages 8–12.

Wallace & Gromit: World of Invention
Lions Gate, 2012, ASIN: B006W4KVI4
The animated characters, Wallace and Gromit, host a humorous BBC One television series about real-life inventions. Appropriate for ages 8 and up. The show's supporting website is archived at www.bbc.co.uk/bbcone/wallaceandgromitand includes a simulated "Wallace's Workshop" and instructions for making small projects.

Design Squad
pbskids.org/designsquad
Design Squad is an Emmy- and Peabody-Award-winning series geared toward youth ages 11–18. Full episodes, projects, games, and a blog are available on the website.

Clips

Grand Challenges for Engineering
www.nae.edu/Activities/Projects/grand-challenges-project/Videos_grandchallenges.aspx
National Academy of Engineering videos provide insights into the Grand Challenges for Engineering, and include interviews with engineering professionals. Appropriate for ages 10 and up.

Sway Fun Accessible Glider
www.youtube.com/watch?v=u-S3p4h1poo
The PlayBooster® Sway Fun® Glider is a real-world example of a wheelchair-accessible seesaw. Appropriate for all ages.

As the Rotor Turns: Wind Power and You
www.teachersdomain.org/resource/psu06-e21.sci.rotor
This lesson plan lists video clips, such as those listed below, about the Bear Creek Wind Farm in Pennsylvania under “Multimedia Resources.” Appropriate for all ages.

“Blade onto Tower”
“Turbine Type and Specs”

EWB-SF: Prototyping Low Cost Wind Turbine at AIDG Guatemala
aidg.org/blog/?p=1035
Tyler Valiquette demonstrates his work with the San Francisco chapter of Engineers Without Borders as part of the Appropriate Technology Design Team, which traveled to Guatemala to build a prototype of their vertical axis wind turbine. Appropriate for ages 5 and up.

Wind Turbine Tour
youtu.be/8lWTQdHEazg
This video follows the maintenance and operations team at the Puget Sound Energy’s Wild Horse Wind and Solar Facility as they climb the interior of a 351-foot-tall wind turbine. Appropriate for ages 8 and up.

“How to Make a Paper Boat, origami,” uploaded by user guiainfantilUS at www.youtube.com/watch?v=hiAWx8odStA
This video offers a step-by-step demonstration of folding a paper boat. Appropriate for ages 9 and up.

Wind Engineers — Vestas Education Series
www.youtube.com/watch?v=N4ZzJWsVe9k
Professionals at Vestas Wind Systems A/S describe their different roles at the company. Appropriate for ages 10 and up.

Green Careers: Clean Energy — Wind Power
www.youtube.com/watch?v=vYSlfE53SFs
This three-minute clip provides insights into the various roles in the wind industry. Appropriate for ages 10 and up.

UC Davis Engineers Lighter Blades for Wind Farms
www.youtube.com/watch?v=hBRfboAscww
This brief news reel showcases a wind farm and the lighter blades developed by University of California–Davis engineer Case van Dam. Appropriate for ages 10 and up.

NMSU Engineers Without Borders Builds Bridge in Nicaragua
youtu.be/PNHe0AsmgFQ
The Engineers Without Borders chapter at New Mexico State University constructed a pedestrian suspension bridge in a small Nicaraguan community, which will allow children to cross the river to attend school — even during the rainy season. Appropriate for ages 8 and up.

Student Work: Engineers Without Borders, Sierra Leone
www.princeton.edu/main/news/archive/S35/77/44O86/index.xml?section=featured
The Engineers Without Borders chapter at Princeton gathered information in Sierra Leone during the initial stages of an infrastructure redevelopment project, addressing access to clean water and sanitation as well as providing safe bridges, in one of the villages.

EWB Thailand 2011
www.youtube.com/watch?v=JAcIIHct3aA
Engineers Without Borders student volunteers installed slow sand filters to supply clean water to villages in Thailand.

UMass Engineers Without Borders Head to Kenya
www.youtube.com/watch?v=AmOJd6LyaMA
Engineers Without Borders student volunteers installed a well to supply clean drinking water to a Kenyan village.

NREL Wind Technology Center
www.youtube.com/watch?v=UzLtaLGowtg
A senior engineer provides a technical tour of the National Wind Technology Center (NWTC). Appropriate for teens and adults.

Planet Forward: Fossil Fuels & Beyond, “Chapter 2 — Follow the Wind”
http://video.pbs.org/video/1095269427/
Chapter 2 is a seven-minute excerpt of the full 2009 episode and features conversation between citizens, experts, and policymakers about wind energy and technology. Appropriate for teens and adults.

Report Card for America’s Infrastructure
www.infrastructurereportcard.org/
The American Society of Civil Engineers offers a series of videos that feature interviews with engineers and descriptions of how certain cities are updating their aging water systems, levees, and transportation. Appropriate for teens and adults.

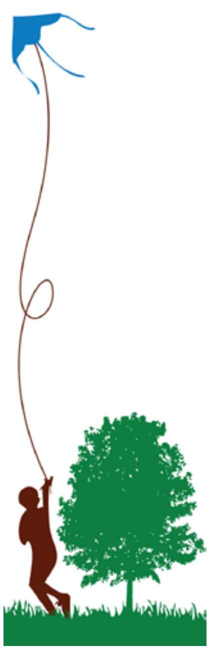
Related Games and Simulations

Engineer It: Test a Paddleboat
www.omsi.edu/exhibits/engineerit/game_paddleboat.php
Children may choose a paddle size and position, then test their simulated boat's speed. Appropriate for ages 10–13.

Math by Design
mathbydesign.thinkport.org
Produced by a national public television collaborative, the online game "Flossville Town Park" incorporates geometry and measurement in the fun context of designing a town park. Appropriate for middle-school students taking Algebra I and II.

PowerUp
www.powerupthegame.com/
Teens, ages about 14 and up, are challenged to save a virtual world from ecological destruction using modern engineering concepts. Supporting lesson plans are provided for high-school teachers. This game is available for download for Windows and Mac computers. PowerUp was created by IBM and TryScience/The New York Hall of Science.

West Point Bridge Designer 2012 Software and West Point Bridge Design Contest
bridgecontest.usma.edu/
The West Point Bridge Designer 2012 software introduces teens to engineering. They are challenged to model, test, and optimize a steel highway bridge. Teachers may be interested in accessing information about the annual West Point Bridge Design Contest through this website. Appropriate for ages 13–18.



Related Products

LEGO™ Education Products
LEGO Education offers products designed for educating ages 18 months and up with LEGO bricks, including StoryStarter, WeDo *Robotics*, and MINDSTORMS™. The website also describes activities that are based on the products.

Squishy Circuits
courseweb.stthomas.edu/apthomas/SquishyCircuits/
Even small children can create circuits using two types of homemade dough and equipment purchased at the Squishy Circuits Store (squishycircuitsstore.com/kits.html) or an electronics store, including a battery pack and fun things that "go": LED lights, a motor, and/or a buzzer. Note their recommendations for cleaning the electronics to prevent corrosion and safety precautions. The website offers video overviews, recipes for the dough, and directions for building circuits.

Further Activities and Lessons

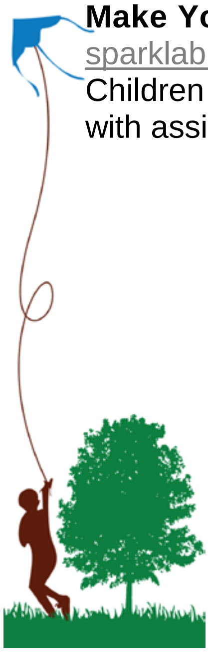
National Renewable Energy Laboratory (NREL) Educational Resources
www.nrel.gov/education/educational_resources.html
NREL provides a list of resources for parents and educators to use with children ages 5–18. The lessons, projects, and references explore renewable energy and energy efficiency technologies and are sorted for different grade levels under topics such as "renewable energy," "wind," and "solar."

ZOOM
pbskids.org/zoom/
While this PBS TV show is no longer being produced, the website describes hands-on activities and provides other resources. The list of projects found at pbskids.org/zoom/activities/build is especially relevant to *Playful Building.* There is also a list of projects, crafts, games, and recipes for preschool-aged children at pbskids.org/zoom/activities/preschool/. Appropriate for use with ages 4 and up.

***Invention at Play*, Smithsonian National Museum of American History**
inventionatplay.org/iapfamilyguide.pdf
(*en Español,* inventionatplay.org/iapfamilyguide_espanol.pdf)
Children ages 10 and under work with an adult to use common materials in engineering design projects.

Draggin' Boats
www.omsi.edu/exhibits/engineerit/draggin.pdf
In this classroom lesson, children create dragon boats using clean, empty 8-oz. milk cartons and a variety of other common objects. They test their boats, and there are options for additional explorations for older children by performing velocity calculations, adding objects to the boat, or floating the boats in saltwater. This Oregon Museum of Science and Industry (OMSI) lesson supports their ENGINEER IT! exhibit. Appropriate for use with ages 5–13.

Make Your Own Wind Turbine, Smithsonian National Museum of American History
sparklab.si.edu/downloads/sparklab-wind.pdf
Children cut out and assemble their own pinwheel. Appropriate for children ages 5–8, with assistance from an adult for pinning the wheel.



Marshmallow Challenge
marshmallowchallenge.com/Instructions.html
Participants work in groups to build a structure — perhaps a feature they'd like to include in their imagined community park — out of spaghetti and balance a marshmallow on its top. With teens and adults, consider showing the TED 2010 talk, "Marshmallow Challenge" (marshmallowchallenge.com/TED_Talk.html) and using the design process concepts discussed there to launch a discussion about engineering and ways to tackle the world's problems. Appropriate for children ages 6 and up.

Fetch! with Ruff Ruffman
pbskids.org/fetch
While this PBS TV show is no longer being produced, resources for leading Fetch! Activities, including activity guides, training videos, and book and website lists, are available at www.pbs.org/parents/fetch/activities. Appropriate for use with children ages 6–12.

How to Make a Paper Boat
www.wikihow.com/Make-a-Paper-Boat
Edits provided by user Brigitta M. and others.

***FIRST* Robotics Competition (FRC)**
www.usfirst.org
FIRST is a robotics program for students aged 6–18. Find out how to get involved at www.usfirst.org/roboticsprograms/frc/get-involved.

PBS Design Squad
pbskids.org/designsquad
Tweens are engaged in a variety of useful building projects. Appropriate for use with ages 9–12.

Hand-Operated Water Pump (Archimedes' Screw)
www.informit.com/articles/article.aspx?p=413663&seqNum=4
Screw pumps — similar to that allegedly invented by the Greek scientist Archimedes — are used even today. The design of the screws is open enough to permit debris to pass through, so they are used to pump sewage in wastewater treatment plants. Challenge tweens and teens to create and test a working screw pump — perhaps to lift "dirty water" up to a second team that is constructing a water filtration system. Water or a small ball can be lifted through flexible tubing wrapped into a spiral, as detailed by this hands-on activity. View a screw pump in action at "Archimedes Screw" at www.youtube.com/watch?feature=fvwp&NR=1&v=kz8Ct-jPkIo.

Explore
www.lpi.usra.edu/explore
The Lunar and Planetary Institute's *Explore* program is designed to engage children in Earth and space science in out-of-classroom environments through hands-on activities. Offer model-building projects, such as spacecraft to explore the Moon or Mars, rockets and space capsules, and space colonies! The materials can be flexibly implemented, and the activities rely on inexpensive, easy-to-find materials. Appropriate for use with children ages 8–13.

Peppy's Day in the Park
www.cmhouston.org/attachments/contentmanagers/45/peppy.pdf
Children ages 8 and up make perimeter and area calculations in the context of seeing how far Peppy, an imagined dog, will walk around the perimeter and run within the whole space of the park.

"Who Dirtied the Water?," Museum of Science and Industry
www.msichicago.org/fileadmin/Education/learninglabs/lab_downloads/TTW_dirtied_the_water_act.pdf
Children are read the story of an imaginary place, where the activities of wildlife and people influence the area's lake. At a key point in the story, each child adds a "pollutant" to the "lake" — usually eliciting an "ewwww!" from the audience! An aquarium or other large container is used to simulate the lake, and common materials like paper, vinegar, and molasses represent the pollutants. The story is used to start a conversation about pollution in our lakes, rivers, oceans, and groundwater. Appropriate for ages 8–13.

Time to Invent
timetoinvent.org
Time to Invent is an afterschool club with activities designed for use with grades 5 and up (or grades 3 and 4 with modifications). The website provides 16 hands-on invention challenges, a training video for club leader(s), and instructions for running a club.

#MAYkerMondays!
www.facebook.com/events/438029042937240
This Facebook page offers a rich vein of information on maker spaces in libraries.

4-H Grab and Go: Kites
University of Illinois, 2009, retrieved through howtosmile.org/record/3442
This instruction sheet describes how to fold a kite and then modify the design to help the kite fly better. Appropriate for ages 8–14.

> **4-H Into the Wind**, "Part 1: The Kite"
> www.youtube.com/watch?v=Pp-If6qQNPk
> This three-minute video uses kites to explain that wind is the movement of air from high to low pressure systems. Appropriate for ages 10 to 14.

KidWind Science Snack: Wind Turbine Blade Design
learn.kidwind.org/teach
Middle- and high-school-aged youth modify a model wind turbine, such as the kit available from store.kidwind.org. They plan a design and test different blade materials (such as cardboard, balsa wood, coroplast, and index cards) or other variables. The models produce electricity, which is measured with a multimeter. A selection of PowerPoint presentations about wind, wind power, and wind turbine technology can support this more advanced investigation into wind energy. Product videos on using a multimeter and the KidWind basic wind experiment kit are available on the site.

Engage children in science crafts and investigations about wind.

Discover Earth: Wind Streamer
www.lpi.usra.edu/explore/discoverEarth/activities/Activity5_Packet.pdf
As a part of the activity "Weather: The Many Faces of Mother Nature," children create a wind streamer out of common materials and use it to determine the wind's direction. Appropriate for ages 4 to 7, with assistance from an adult for cutting.

Discover Earth: Winds
www.lpi.usra.edu/explore/discoverEarth/activities/Activity6_Packet.pdf
As part of the activity "Weather Stations," children investigate the source of wind. They use a toaster to heat air and observe the movement of a small aluminum foil kite — due to wind! They compare the appliance's heat source to Earth's warmed surface and discover that wind is a type of convection. Appropriate for ages 8 to 13.

"Water: No Dirt, No Germs," Global Experiment for the International Year of Chemistry
www.americanchemistry.com/Global-Experiment-for-the-International-Year-of-Chemistry—Water-No-Dirt-No-Germs
Created for the International Year of Chemistry, 2011, students treat water from a natural local source in this lesson. They undertake a four-step process to clarify the water, which includes filtering it through layers of sand and pebbles. They disinfect the water (younger students observe this as a demonstration). Appropriate for use with ages 10 and up.

"Water Filtration using Fabric" Instructables
Posted under username "Danger is my middle name."
www.instructables.com/id/Water-Filtration-using-Fabric/
This investigation was originally conducted at the college level, but it could be modified for use with children and teens. To conduct the turbidity measurements suggested in the procedure, consider using a transparency tube purchased from a science education supplier, such as WARD's Natural Science (wardsci.com).

Presentations by Experts (e.g., podcasts, video clips, and slides)

"Milena Boniolo — Using bananas to clean water in Brazil," TEDFellowsTalks, Sep 2, 2010
http://www.youtube.com/watch?v=_RTS0I3m2kg
Brazilian chemistry graduate student Milena Boniolo found a way to use banana peels to clean water! She explains her process in this TED talk. Her work is also described in "Fruity Filter," The Loh Down On Science radio program: staging.scprdev.org/programs/loh-down-on-science/2011/06/27/25202/fruity-filter. Appropriate for ages 10 and up.

This selection of video clips explores how engineers are designing, testing, and modifying wind turbines to generate electricity:

- Wind Engineers — Vestas Education Series
  www.youtube.com/watch?v=N4ZzJWsVe9k
- Engineer YouTube clip: www.youtube.com/watch?v=vYSlfE53SFs
- Wind Turbine Tour: youtu.be/8lWTQdHEazg
- UC Davis Engineers Lighter Blades for Wind Farms:
  www.youtube.com/watch?v=hBRfboAscww

Engines of Our Ingenuity
www.uh.edu/engines
Produced by KUHF-FM Houston, this radio program discusses inventions, inventors, and human creativity. Recent episodes are available for download as podcasts, and all episodes are available as transcripts. Writer and host John Lienhard is Professor Emeritus of Mechanical Engineering and History at the University of Houston. Appropriate for ages 14 and up.

Outreach Suggestions

National Girls Collaborative Project
www.ngcproject.org
The National Girls Collaborative Project™ (NGCP) is designed to reach girl-serving STEM organizations across the United States.

Aspire
aspire.swe.org
This Society of Women Engineers (SWE) K–12 outreach program offers resources and events designed to share the excitement of engineering with girls in grades K–12.

National Engineers Week Foundation
www.eweek.org
As part of its signature program of over 60 years, ENGINEERS WEEK®, this foundation hosts Introduce a Girl to Engineering Day® and Discover Engineering Family Day. Students in grades 6–8 can also participate in the Annual Future City® Competition, where teams work with educators and engineer mentors to design a city 150 years into the future using SimCity™ 4 Deluxe software.

Correlations to National Standards

The activities in this module support several nationally-recognized technology standards, including the list below, which are quoted from the *National Science Education Standards* (National Academies Press, 1996). Engineering standards have not been fully addressed at the national level; references listed below provide further information on the status of this evolving dialogue in the education community.

National Science Education Standards

Grades K–4

Science and Technology — Content Standard E
Abilities of Technological Design

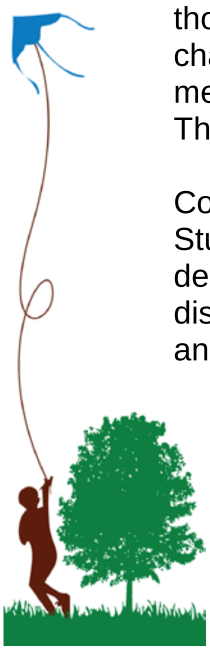
Identify a Simple Problem
In problem identification, children should develop the ability to explain a problem in their own words and identify a specific task and solution related to the problem.

Propose a Solution
Students should make proposals to build something or get something to work better; they should be able to describe and communicate their ideas. Students should recognize that designing a solution might have constraints, such as cost, materials, time, space, or safety.

Implementing Proposed Solutions
Children should develop abilities to work individually and collaboratively and to use suitable tools, techniques, and quantitative measurements when appropriate. Students should demonstrate the ability to balance simple constraints in problem solving.

Evaluate a Product or Design
Students should evaluate their own results or solutions to problems, as well as those of other children, by considering how well a product or design met the challenge to solve a problem. When possible, students should use measurements and include constraints and other criteria in their evaluations. They should modify designs based on the results of evaluations.

Communicate a Problem, Design, and Solution
Student abilities should include oral, written, and pictorial communication of the design process and product. The communication might be show and tell, group discussions, short written reports, or pictures, depending on the students' abilities and the design project.



Understandings about Science and Technology

- People have always had problems and invented tools and techniques (ways of doing something) to solve problems.
- Scientists and engineers often work in teams with different individuals doing different things that contribute to the results. This understanding focuses primarily on teams working together, and secondarily on the combination of scientist and engineer teams.
- Women and men of all ages, backgrounds, and groups engage in a variety of scientific and technological work.

Grades 5-8

Science and Technology — Content Standard E

Abilities of Technological Design

Identify Appropriate Problems for Technological Design
Students should develop their abilities by identifying a specified need, considering its various aspects, and talking to different potential users or beneficiaries. They should appreciate that for some needs, the cultural backgrounds and beliefs of different groups can affect the criteria for a suitable product.

Design a Solution or Product
Students should make and compare different proposals in the light of the criteria they have selected. They must consider constraints — such as cost, time, trade-offs, and materials needed — and communicate ideas with drawings and simple models.

Implement a Proposed Design
Students should organize materials and other resources, plan their work, make good use of group collaboration where appropriate, choose suitable tools and techniques, and work with appropriate measurement methods to ensure adequate accuracy.

Evaluate Completed Technological Designs or Products
Students should use criteria relevant to the original purpose or need, consider a variety of factors that might affect acceptability and suitability for intended users or beneficiaries, and develop measures of quality with respect to such criteria and factors; they should also suggest improvements and, for their own products, try proposed modifications.

Communicate the Process of Technological Design
Students should review and describe any completed piece of work and identify the stages of problem identification, solution design, implementation, and evaluation.

Understandings about Science and Technology

- …[E]ngineers propose solutions relating to human problems, needs, and aspirations.
- Many different people in different cultures have made and continue to make contributions to science and technology.
- Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, or effects of weather and friction; other constraints limit choices in the design, for example, environmental protection, human safety, and aesthetics.

Science in Personal and Social Perspectives — Content Standard F

- Technology influences society through its products and processes. Technology influences the quality of life and the ways people act and interact. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and to society. Social needs, attitudes, and values influence the direction of technological development.
- Science and technology have advanced through contributions of many different people, in different cultures, at different times in history. Science and technology have contributed enormously to economic growth and productivity among societies and groups within societies.
- Scientists and engineers work in many different settings, including colleges and universities, businesses and industries, specific research institutes, and government agencies.

History and Nature of Science — Content Standard G
Science as a Human Endeavor

- Women and men of various social and ethnic backgrounds — and with diverse interests, talents, qualities, and motivations — engage in the activities of science, engineering, and related fields such as the health professions...

Grades 9-12

Science and Technology — Content Standard E
Understandings about Science and Technology

- Creativity, imagination, and a good knowledge base are all required in the work of science and engineering.
- …[T]echnological design is driven by the need to meet human needs and solve human problems. Technology, by its nature, has a more direct effect on society than science because its purpose is to solve human problems, help humans adapt, and fulfill human aspirations...

Science in Personal and Social Perspectives — Content Standard F
Science and Technology in Local, National, and Global Challenges

- Science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen. The latter involves human decisions about the use of knowledge.

- Progress in science and technology can be affected by social issues and challenges. Funding priorities for specific health problems serve as examples of ways that social issues influence science and technology.

History and Nature of Science — Content Standard G
Science as a Human Endeavor

- Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem. Pursuing science as a career or as a hobby can be both fascinating and intellectually rewarding.

References

National Research Council. *National Science Education Standards*. Washington, DC: The National Academies Press, 1996.

National Research Council. *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Committee on a Conceptual Framework for New K–12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press, 2012.

International Technology Education Association. Standards for Technological Literacy: Content for the Study of Technology*. www.iteea.org/TAA/PDFs/xstnd.pdf,* 2007.

Contact Information

Your questions and comments about *Playful Building* are welcome!

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STAR_Net Project Overview

The *STAR_Net* project has a number of components, including:

- Two traveling exhibits for libraries: *Discover Earth: A Century of Change,* and *Discover Tech: Engineers Make a World of Difference*.
- An Education Program, which includes developing exemplary hands-on activities for libraries, as well as conducting training (both online and in-person) for library staff.
- An Outreach Program that helps libraries to develop STEM programming and find local partners for collaborations on programming.
- An online Community of Practice (CoP) (community.discoverexhibits.org) for librarians (both hosts and non-hosts of the exhibits) and STEM professionals who want to support STEM programming in public libraries.

The National Science Foundation (NSF) provided funding for the *STAR_Net* project. *STAR_Net* is led by the National Center for Interactive Learning (NCIL) at the Space Science Institute. Dr. Paul Dusenbery is the project director. STAR stands for “Science-Technology Activities and Resources.” In addition to NCIL staff, the project team includes:

- The American Library Association (ALA), which is managing the exhibit tours and helping to raise awareness among librarians of the many opportunities for providing STEM programming.
- The Lunar and Planetary Institute (LPI), which is leading the Education Program component. For 15 years, LPI has led the *Explore* program for libraries, which has been at the forefront of developing STEM programming and training for librarians.

- The National Girls Collaborative Project (NGCP), which is leading the project's Outreach Program. As a project partner, this NSF-funded project is helping libraries across the country partner with a variety of organizations to provide STEM programming.
- Staff from NCIL and Evaluation and Research Associates are conducting evaluations of the project's components. The project also includes a research component that explores how public libraries can serve as STEM learning centers in rural, underserved communities. The evaluation and research results will be shared with the informal science education community.

Online Community

Librarians, scientists, engineers, educators, museum staff, and others are invited to join the *STAR_Net* online community! The website fosters collaboration among professionals who want to provide or support science, technology, engineering, and mathematics (STEM) learning experiences in libraries. Please join the online community (http://community.starnetlibraries.org) and share your experiences implementing *Playful Building* with your colleagues.

For more information about the *STAR_Net* project, please contact:

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