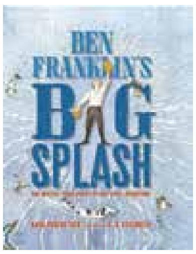
Inventions Take Center Stage

By Christine Anne Royce

According to *A Framework for K–12 Science Education*, elementary students should know that "[m]aterials can be characterized by their intensive measurable properties … and are suited to different use" (NRC 2012, p. 107).

By understanding the different types of properties and uses materials have, students learn that "[a] great variety of objects can be built up from a small set of pieces" (NRC 2012, p. 108). Both of this month's books show how an invention is made of parts that help it solve a problem. The accompanying activities allow students to consider the many individual parts that are used to make an object.

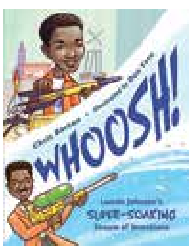
This Month's Trade Books



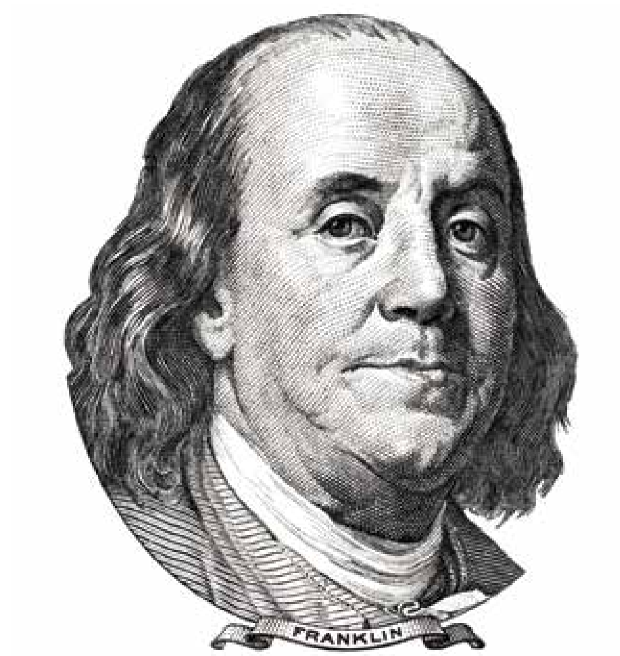
Ben Franklin's Big Splash
By Barb Rosenstock
Illustrated by S.D. Schindler
ISBN: 978-1-62091-446-5
Calkins Creek
32 pages
Grades K–2

Synopsis

This book explains how Benjamin Franklin's first invention helped him with his favorite pastime: swimming. The story takes the reader on a journey of experimentation to show how Franklin built swim paddles.



Woosh! Lonnie Johnson's Super-Soaking Stream of Inventions
By Chris Barton
Illustrated by Don Tate
ISBN: 978-1-58089-297-1
Charlesbridge
32 pages
Grades 2–5



Synopsis

This book tells the story of how Lonnie Johnson combined his love for inventions and his creativity to create the famous Super Soaker water gun. He assembled various parts to create a new cooling system, and his subsequent invention made waves in the toy world. ■

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References

National Governors Association Center for Best Practices and Council of Chief State School Officers (NGAC and CCSSO). 2010. *Common core state standards*. Washington, DC: NGAC and CCSSO.

National Research Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academies Press.

NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press. *www.nextgenscience.org/next-generation-science-standards*.

Zelver, P. 1994. *The wonderful towers of Watts.* Honesdale, PA: Boyd Mills Press.

NSTA Connection

Download text suggestions and student data sheets at *www.nsta.org/SC1711*.

Grades K–2: Putting the Parts Together

Materials

- swim devices (e.g., kickboard, life preserver, swim fins, floating tube, pool noodles)
- *Ben Franklin's Big Splash*
- Swimtastic Student Data Sheet (see NSTA Connection)
- *The Wonderful Towers of Watts* (Zelver 1994)
- video resources (see Internet Resources)
- large tub of water

Purpose

To identify different types of materials in objects that help people float or swim better, and to examine pictures to determine what individual parts make up a larger object.

Engage

Although Benjamin Franklin is known for many inventions, swimming paddles are not usually ones associated with him. Explain to students that when Franklin was an 11-year-old boy, he loved to swim and wanted to swim like a fish. Have students brainstorm a list of devices that have helped them swim or float better. (Before class, gather as many of these devices as possible and keep them hidden.) Read *Ben Franklin's Big Splash* to the class and stop at the following pages to engage students:

- Franklin looking at the shape of a fish: On this page, Franklin examines the shape of fish and how they swim. Using the pictures of the fish in the book or other pictures of fish, ask students to consider what about the shape of the fish makes them "speedy swimmers." Ask students to consider what about Franklin's hands reminded him of fish.
- Franklin designing his first invention: Ask students to look at what Franklin is visualizing about fish fins and then explain why his first invention (hand paddles) might help him swim like a fish.
- The page before Franklin's swim sandals: Discuss the last set of text on the page where Franklin is looking at the fish. Ask students to compare Franklin's swim paddles with the fish. Ask students, "If a set of swim paddles represents a set of fins, where has Ben been successful in 'swimming like a fish,' and where does he need to improve?"

In the end, Franklin was not successful in swimming like a fish; however, his attempts at inventing fins do show that he knew about properties of materials.

Explore

After reading and discussing the book, take out the swim devices and ask groups of students to examine each object to determine what type of material it is made of, how its shape helps people swim better, and whether it is suited to the following tasks:

- float in water better,
- swim faster by kicking harder,
- keep your head above water,
- allow you to float on water, and
- provide flexibility and wrap around you as you float.

Allow students to test the objects (without actually swimming) in large tub of water and have them watch short videos about the objects (see Internet Resources). If an object is too big, as is the case with a pool noodle, provide students with a part of the object to test. As groups of students examine the objects, ask them to record their observations on their Swimtastic Student Data Sheet (see NSTA Connection).

CAUTION

It is best to conduct this activity outside in a grassy area to prevent making a mess in the classroom and help prevent safety issues with wet floors. Regardless of where you do this activity, make sure that students do not enter the water, even if it is a shallow pool. To reduce the risk of students slipping on wet floors, ask them to sit or kneel around the water and wait for directions to stand up and walk around.

Explain

Have each group randomly select one potential use for the devices by picking a card with a task written on it from a hat or bowl. Then, ask groups to identify an object that best accomplishes the goal and present their reasoning to the class. Students should answer the following questions as they prepare their presentation:

- What object did you select for your task?
- What type of material is the object made of? Is it made of more than one type of material?
- What helps the object float in water (e.g., air, type of material)? What about this device helps a person swim better?
- What are your reasons for selecting this object?

- What could be improved in this object to help it float better? How can this object be redesigned to help someone swim better?

Allow other groups to ask questions as students give their presentations. After all groups have presented, ask them to return to the story about Benjamin Franklin. Many of the materials we have today were not available during his time. Ask groups to choose a modern material that would be best for Franklin's paddles, and then ask them to explain their reasoning.

Elaborate

During this phase, students discuss how the pieces of an object can be disassembled and used to create a new object. Show students the cover of *The Wonderful Towers of Watts* and ask them what they see. This book tells the story of the Italian artist who used recycled materials to create a series of interconnecting towers in Los Angeles. Read the book to the class and ask students to examine the pictures in the book, in a video clip (see Internet Resources), or online (see Internet Resources) and make a list of the objects they see in the towers.

For example, there are pieces of glass, pottery, metal, and cement in the structures. Ask students to consider the different objects they see in these towers. Illustrate a new tower and label the different objects they would use. Ask students, "How is your tower similar to the Watts Towers, and how is it different?"

Evaluate

This investigation allows students to explore the materials that make up objects, use objects for a particular purpose, and consider how the objects' components can make something new. Students are asked to show their initial understanding of objects, test objects, make decisions to accomplish a task, and apply their understanding in the Elaboration phase.

Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013):

K–2: Putting the Parts Together

2-PS1-3: Matter and Its Interactions

www.nextgenscience.org/pe/2-ps1-3-matter-and-its-interactions

The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities. The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectation listed below.

Performance Expectation	Connections to Classroom Activity *Students:*
2-PS1-3. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.	• examine the materials that make up the Watts Towers and propose a new structure using the same types of materials.
Science and Engineering Practice	
Constructing Explanations and Designing Solutions	• after testing objects, determine which objects would help them accomplish a task related to floating or swimming.
Disciplinary Core Idea	
PS1.A: Structure and Properties of Matter • Different properties are suited to different purposes. • A great variety of objects can be built up from a small set of pieces.	• identify the materials that make up different objects designed to help them float or swim.
Crosscutting Concept	
Energy and Matter	• recommend a particular object based on their testing to accomplish a task in the water.

Grades 3–5: It's Getting Hot

Purpose

To examine the design process through the construction and modification of a solar pizza box oven.

Materials

- *Woosh! Lonnie Johnson's Super-Soaking Stream of Inventions*
- plastic wrap, foil, pizza box, black paper, newspaper
- thermometers
- tape, scissors
- blanket
- graham crackers, marshmallows, chocolate bars
- It's Getting Hot Data Sheet (see NSTA Connection)

Engage

Read *Woosh! Lonnie Johnson's Super-Soaking Stream of Inventions* to the class. While reading the book, ask students to consider the following questions:

- As a child and young man, Lonnie considered himself an inventor. What were some of the devices he invented? Did his inventions always work the first time? What did he do when they didn't?
- When he worked at NASA, what did he have to design for the *Galileo* space probe? What does a power supply do?
- When he was working on designing a cooling system, what did he accidently invent? How was it different from a normal water gun?
- What is an early version of an invention called? Why do engineers build prototypes?
- Pumping a Super Soaker creates a buildup of air pressure. Afterward, what happens when a Super Soaker is fired?

Lonnie Johnson

The book reveals two key points. First, the Super Soaker's pump compresses air, which builds up energy that is released when the trigger is pulled, resulting in an energy transfer. Second, engineers and inventors design, test, and tweak ideas to make them more efficient in meeting a task.

Explore

After reading the story, introduce the idea that different inventions can use different types of energy to accomplish a desired outcome. Ask students to name types of energy they are familiar with, which may include electricity that illuminates lights, fuel that makes cars move, and wind that helps turn a windmill. After discussing different types of energy with students, introduce the idea that the Sun produces energy that travels to Earth, or *solar energy*.

Pose the following challenge to the students: "Lonnie tried to invent things that would help him do something or meet a need in society. Your challenge is to create a pizza box solar oven that can melt the marshmallow in a s'more."

Although there are many different ways to make a pizza box solar oven, this particular set of directions is adapted from an article in *Scientific American* (see Internet Resources). The overall concept of how the oven works is described in this column, and the specific directions are available in the article. The materials are listed above.

First, a flap is cut into the top of a pizza box and covered with foil, which reflects sunlight into the box. The window is sealed with plastic wrap to retain the Sun's heat energy, and black paper lines the bottom of the box to absorb that energy. Once students have built this basic solar oven, ask them to take some temperature readings by placing one thermometer in the box and one outside of the box. Ask them to do this three times, allowing 20 minutes to pass between the readings. As students monitor the temperature, ask them to record their data on the It's Getting Hot Data Sheet (see NSTA Connection). Because all of the original designs will be the same, students can also compare notes as to how the placement of their oven affected the temperature readings. While students are waiting to see how warm their solar ovens become, ask them to consider how they can tweak the design to make it more efficient:

- How can you adjust the angle of the reflector flap to increase its efficiency?
- What different materials can be used to insulate the box's sides? The box's bottom? (Rolling newspaper into 1 or 1.5 in. rolls and taping them around the inside of the box edges will help insulate it. Placing the box on a blanket on the ground will help prevent heat loss if the ground is cooler than the air.)

- Is there a better time of the day to place the solar oven outside?

After students choose some oven modifications and sketch their new design on their data sheet, ask them to take another set of temperature readings on a different day, after making one change to their oven. Retest on a day that has a similar outside temperature and similar cloud cover. Students can try to melt the marshmallow and chocolate on a s'more. Remind students to follow school safety guidelines related to food and allergies.

CAUTION

Explain

After students build the pizza box solar oven and make observations on how different variables affect its temperature, ask them to report their findings to the class. These presentations are similar to what Lonnie was asked to do while working on the *Galileo* probe and visiting toy companies to sell his Super Soaker. Students should discuss their initial design, the modifications they made to it, and how those modifications affected the temperature readings over time. Ask students, "Did the temperature go up, remain the same, or drop after you made your modifications?"

Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013):

3–5: It's Getting Hot

4-PS3: Energy

www.nextgenscience.org/dci-arrangement/4-ps3-energy

The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities. The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectation listed below.

Performance Expectation	**Connections to Classroom Activity** *Students:*
4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	• build a prototype of a pizza box solar oven and make modifications to increase its efficiency.
Science and Engineering Practices	
Planning and Carrying Out Investigations Constructing Explanations and Designing Solutions	• determine the temperature change in a pizza box solar oven over time and use the data to design an improved cooker.
Disciplinary Core Ideas	
PS3.D: Energy in Chemical Processes and Everyday Life • The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use.	• explain how the Super Soaker and solar pizza box oven use energy to accomplish a task.
ETS1.A: Defining Engineering Problems • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.	• engage in two different design challenges, during which a prototype for each must first be constructed and then modified to increase efficiency.
Crosscutting Concept	
Energy and Matter	• examine how solar energy is transformed into heat energy to make a s'more.

Elaborate

Ask students to consider other ways they can use solar energy to heat things. Introduce the idea that solar energy is often used to heat water. Students can engage in a PBS Kids Design Squad Challenge (see Internet Resources), during which they design and build a solar water heater, and then try to increase its temperature.

Evaluate

Students are first asked to consider what they know about inventors and the design process as they listen to the story about Lonnie Johnson. Then they are asked to apply their understanding of the design process when designing the pizza box solar oven. Finally, students design a solar water heater, measure the temperature of the water, then make modifications to their design to determine whether they can increase the temperature of the water.

Internet Resources

Feel the Heat Design Squad Challenge
http://to.pbs.org/2wlZbYb
Floating With a Life Jacket
www.youtube.com/watch?v=kwtJyG_79ts
Floating With Pool Noodles
www.youtube.com/watch?v=9-NNLYHe2Ow
How to Kick With Swim Fins
www.youtube.com/watch?v=dTRFjggtFC4
How to Use a Kickboard
www.youtube.com/watch?v=iM3z1eDDcGE
Pictures and History of the Watts Towers
http://bit.ly/2iF6qqW
Pizza Box Solar Oven
http://bit.ly/2wQE9nI
The Watts Towers
www.youtube.com/watch?v=7OwpA2MOcJ0

Connecting to the *Common Core State Standards* (NGAC and CCSSO 2010):

This section provides the *Common Core State Standards for English Language Arts and/or Mathematics* addressed in this column to allow for crosscurricular planning and integration. The Standards state that students should be able to do the following at grade level.

English Language Arts

Reading Standards for Informational Text K–5 – Key Ideas and Details

- Grade 4: "Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text."

Writing Standards Research to Build and Present Knowledge

- Grade K: "With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question."
- Grade 4: "Recall relevant information from experiences or gather relevant information from print and digital sources, take notes and categorize information, and provide a list of sources."

Writing Standards K–5 – Text Types and Purposes

- Grade K: "Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic."
- Grade 4: "Write informative/explanatory texts to examine a topic and convey ideas and information clearly."

Speaking and Listening Standards K–5 – Presentation of Knowledge and Ideas

- Kindergarten: "Add drawings or other visual displays to descriptions as desired to provide additional details."
- Grade 1: "Add drawings or other visual displays to descriptions when appropriate to clarify ideas, thoughts, and feelings."

Vocabulary Acquisition and Use is one of the strands in the language standards. This particular strand appears across grade levels. "Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade [appropriate] reading and content."

Furthermore, the *Common Core for ELA* provide a standard related to the Range of Text Types for K–5 where it indicates that students in K–5 should apply the Reading standards to a wide range of texts to include informational science books.