EVEN MORE Picture-Perfect SCIENCE Lessons, K–5

Using Children's Books to Guide Inquiry

by Emily Morgan and Karen Ansberry

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National Science Teachers Association

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Contents

Preface

A class of fifth-grade students listen as their teacher reads *The Boy Who Harnessed the Wind*. This is the true story of William Kamkwamba, a 14-year-old African boy whose perseverance and ingenuity brought electricity and running water to his drought-ravaged village. With nothing but scraps from a junkyard and the knowledge he acquired from library books, William built a windmill and waited for the wind. Students sit in awe as the teacher reads the dramatic account of what happened next. "Like always, it came, first a breeze, then a gusting gale. The tower swayed and the blades spun round. With sore hands once slowed by hunger and darkness William connected wires to a small bulb, which flickered at first, then surged as bright as the sun. 'Tonga!' he shouted. 'I have made electric wind!'" The teacher asks the class, "How do you think William's windmill was able to light a lightbulb?" In a lesson inspired by this extraordinary story (Chapter 9, "Harnessing the Wind"), students discover the answer to this question by first investigating how a simple handheld generator, the Dynamo Torch, transforms energy of motion into electrical energy. Students then build on this experience by reading an article about energy transformations and listening to a nonfiction read-aloud that explains how wind turbines produce electricity. Eventually, students develop explanations that explain how William's windmill was able to light a bulb. They elaborate on what they have learned by researching various energy resources. Through hands-on inquiries and high-quality readings and picture books, students learn difficult concepts about energy—all within the context of William's remarkable true story.

What Is Picture-Perfect Science?

This scenario describes how a children's picture book can help guide students through an engaging, hands-on inquiry lesson. *Even More Picture-Perfect Science Lessons, K–5* contains 20 science lessons for students in grades K through 5, with embedded reading comprehension strategies to help them learn to read and read to learn while engaged in inquiry-based science. To help you teach according to *A Framework for K–12 Science Education* (NRC 2012), the lessons are written in an easy-to-follow format for teaching inquiry-based science according to the BSCS 5E Instructional Model (Bybee 1997, used with permission from BSCS; see Chapter 4 for more information). This learning cycle model allows students to construct their own understanding of scientific concepts as they cycle through the following phases: engage, explore, explain, elaborate, and evaluate. Although *Even More Picture-Perfect Science Lessons* is primarily a book for teaching science, reading comprehension strategies and the Common Core State Standards for English Language Arts (Common Core ELA; NGA for Best Practices and CCSSO 2010) are embedded in each lesson. These essential strategies can be modeled while keeping the focus of the lessons on science.

Use This Book Within Your Science Curriculum

We wrote *Even More Picture-Perfect Science Lessons* to supplement, not replace, an existing science program. Although each lesson stands alone as a carefully planned learning cycle based on clearly defined science objectives, the lessons are intended to be integrated into a more complete unit of instruction in which concepts can be more fully developed. The lessons are not designed to be taught sequentially. We want you to use the lessons where appropriate within your school's current science curriculum to support, enrich, and extend it. And we want you to adapt the lessons to fit your school's curriculum, your students' needs, and your own teaching style.

Special Features

Ready-to-Use Lessons With Assessments

Each lesson contains engagement activities, hands-on explorations, student pages, suggestions for student and teacher explanations, opportunities for elaboration, assessment suggestions, and annotated bibliographies of more books to read on the topic. Assessments include poster sessions with rubrics, teacher checkpoint labs, and formal multiple-choice and extended-response questions.

Reading Comprehension Strategies

Reading comprehension strategies based on the book *Strategies That Work* (Harvey and Goudvis 2000) and specific activities to enhance comprehension are embedded throughout the lessons and clearly marked with an icon. Chapter 2 describes how to model these strategies while reading aloud to students.

Standards-Based Objectives

All lesson objectives are grade-level endpoints from *A Framework for K–12 Science Education* (NRC 2012) and are clearly identified at the beginning of each lesson. Because we wrote *Even More Picture-Perfect Science Lessons* for students in grades K–5, we used two grade ranges of the *Framework:* K–2 and 3–5. Chapter 5, "Connecting to the Standards," outlines the component ideas from the *Framework* and the grade band addressed for each lesson.

The lessons also incorporate the Common Core State Standards for English Language Arts. In a box titled "Connecting to the Common Core" you will find the Common Core ELA strand the activity addresses (e.g., reading, writing, speaking and listening, or language) as well as the grade level and standard number (e.g., K.9 or 5.1). You will see that writing assignments are specifically labeled with an icon.

Science as Inquiry

As we said, the lessons in *Even More Picture-Perfect Science Lessons* are structured as guided inquiries following the 5E Model. Guiding questions are embedded throughout each lesson and marked with an icon **?**. The questioning process is the cornerstone of good teaching. A teacher who asks thoughtful questions arouses students' curiosity, promotes critical-thinking skills, creates links between ideas, provides challenges, gets immediate feedback on student learning, and helps guide students through the inquiry process. Chapters 3 and 4 explore science as inquiry and the BSCS 5E Instructional Model, and each lesson includes an "Inquiry Place" box that suggests ideas for developing open inquiries.

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Kamkwamba, W., and B. Mealer. 2012. *The boy who harnessed the wind.* New York: Dial Books for Young Readers.

Editors' Note

Even More Picture-Perfect Science Lessons builds on the texts of 31 children's picture books to teach science. Some of these books feature animals that have been anthropomorphized, such as a caterpillar that does magic tricks. While we recognize that many scientists and educators believe that personification, teleology, animism, and anthropomorphism promote misconceptions among young children, others believe that removing these elements would leave children's literature severely underpopulated. Furthermore, backers of these techniques not only see little harm in their use but also argue that they facilitate learning.

Because *Even More Picture-Perfect Science Lessons* specifically and carefully supports scientific inquiry—the "Amazing Caterpillars" lesson, for instance, teaches students how to weed out misconceptions by asking them to point out inaccurate information about caterpillars and butterflies in a storybook—we, like our authors, feel the question remains open.

Acknowledgments

We would like to dedicate this book to the memory of Sue Livingston, who opened our eyes to the power of modeling reading strategies in the content areas and for teaching us that every teacher is a reading teacher.

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Contributors

Ideas and activities for the lessons in this book were contributed by the following talented, dedicated teachers. We thank them for their creativity, willingness to share, and the important work they do each day in their classrooms.

Jackie Anderson is a multiple disabilities teacher at Roselawn Condon School in Cincinnati, Ohio. Jackie contributed to Chapter 11, "Do You Know Which Ones Will Grow?"

Missy Breuer is a fifth-grade teacher at Pattison Elementary School in Milford, Ohio. Missy contributed to Chapter 20, "Problem Solvers."

Tim Breuer is a seventh-grade teacher at Milford Junior High School in Milford, Ohio. Tim contributed to Chapter 18, "What Will the Weather Be?"

Katie Davis is a second-grade teacher at Mason Early Childhood Center in Mason, Ohio. Katie contributed to Chapter 14, "Ducks Don't Get Wet"; Chapter 16, "Fossils Tell of Long Ago"; and Chapter 17, "Reduce, Reuse, Recycle."

Allyson Day is a sixth-grade math and science teacher at Monroe Elementary School in Monroe, Ohio. Allyson contributed to Chapter 7, "Float Your Boat."

Jenny DeBord is a first-grade teacher at Monroe Primary School in Monroe, Ohio. Jenny contributed to Chapter 7, "Float Your Boat."

Jenny Doerflein is certified to teach art K–12. Jenny contributed to Chapter 11, "Do You Know Which Ones Will Grow?"

Karen Eads is a first-grade teacher at Sharpsburg Elementary School in Norwood, Ohio. Karen contributed to Chapter 6, "Freezing and Melting."

Maria Eshman is a first-grade teacher at Sharpsburg Elementary School in Norwood, Ohio. Maria contributed to Chapter 6, "Freezing and Melting."

Faye Harp is a teaching and learning consultant at Lakota Local Schools in West Chester, Ohio. Faye contributed to Chapter 12, "Seeds on the Move."

Kathy Gall is a second-grade teacher at Monroe Primary School in Monroe, Ohio. Kathy contributed to Chapter 7, "Float Your Boat."

Aubrey McCalla teaches first grade at Williamsburg Elementary School in Williamsburg, Ohio. Aubrey contributed to Chapter 11, "Do You Know Which Ones Will Grow?"

Michelle Gallite is a third-grade teacher at Western Row Elementary School in Mason, Ohio. Michelle contributed to Chapter 8, "The Wind Blew," and Chapter 15, "Amazing Caterpillars."

Colleen Phillips-Birdsong taught second grade for 11 years and now is a Reading Recovery teacher and reading specialist at Mercer Elementary School in Cincinnati. Colleen contributed to Chapter 10, "Sounds All Around"; Chapter 13, "Unbeatable Beaks"; and Chapter 19, "Sunsets and Shadows."

Lisa Haines is a title one reading teacher at Wilmington City Schools in Wilmington, Ohio. Lisa contributed to Chapter 11, "Do You Know Which Ones Will Grow?"

Katie Woodward is a second-grade teacher at Monroe Primary School in Monroe, Ohio. Katie contributed to Chapter 7, "Float Your Boat."

About the Authors

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Karen Ansberry is an elementary science curriculum leader and former fifth- and sixth-grade science teacher at Mason City Schools in Mason, Ohio. She has a bachelor of science in biology from Xavier University and a master of arts in teaching from Miami University. Karen lives in historic Lebanon, Ohio, with her husband, two sons, two daughters, and too many animals.

Emily and Karen, along with language arts consultant Sue Livingston, received a Toyota Tapestry grant for their Picture-Perfect Science grant proposal in 2002. Since then, they have enjoyed facilitating teacher workshops at elementary schools, universities, and professional conferences across the country. This is Emily and Karen's third book in the *Picture-Perfect Science Lessons* series.

Emily and Karen would like to dedicate this book to the memory of Sue Livingston.

About the Picture-Perfect Science Program

The Picture-Perfect Science program originated from Emily Morgan's and Karen Ansberry's shared interest in using children's literature to make science more engaging. In Emily's 2001 master's thesis study involving 350 of her third-grade science lab students at Western Row Elementary, she found that students who used science trade books instead of the textbook scored significantly higher on district science performance assessments than students who used the textbook only. Convinced of the benefits of using picture books to engage students in science inquiry and to increase science understanding, Karen and Emily began collaborating with Sue Livingston, Mason's elementary language arts curriculum leader, in an effort to integrate literacy strategies into inquiry-based science lessons. They received grants from the Ohio Department of Education (2001) and Toyota Tapestry (2002) to train all third- through sixth-grade science teachers, and in 2003 they also trained seventh- and eighth-grade science teachers with district support. The program has been presented at elementary schools, conferences, and universities nationwide.

For more information on Picture-Perfect Science teacher workshops, go to *www.pictureperfectscience.com.*

Lessons by Grade

Chapter	Grade	Picture Books
6	K–2	*Wemberly's Ice-Cream Star* *Why Did My Ice Pop Melt?*
7	3–5	*Toy Boat* *Captain Kidd's Crew Experiments With Sinking and Floating*
8	3–5	*The Wind Blew* *I Face the Wind*
9	3–5	*The Boy Who Harnessed the Wind* *Wind Energy: Blown Away!*
10	K–2	*What's That Sound?* *Sounds All Around*
11	K–2	*Do You Know Which Ones Will Grow?* *What's Alive?*
12	K–2	*Flip, Float, Fly: Seeds on the Move* *Who Will Plant a Tree?*
13	K–2	*Unbeatable Beaks* *Beaks!*
14	3–5	*Just Ducks!* *Ducks Don't Get Wet*
15	K–2	*Houdini the Amazing Caterpillar* *From Caterpillar to Butterfly* *The Very Hungry Caterpillar*
16	3–5	*Fossil* *Fossils Tell of Long Ago*
17	K–2	*The Three R's: Reuse, Reduce, Recycle* *Michael Recycle*
18	3–5	*Come On, Rain!* *What Will the Weather Be?*
19	3–5	*Twilight Comes Twice* *Next Time You See a Sunset*
20	3–5	*Now & Ben: The Modern Inventions of Benjamin Franklin* *Build It: Invent New Structures and Contraptions*

The Wind Blew

Description

What is wind? What is it made of? What can it do? In this lesson, students explore ways to change the speed and direction of a Ping-Pong ball using a handheld air pump to simulate wind. Simple experiments help them understand that air has weight and moving air applies a force to objects. Students investigate how wind strength, opposing wind force, and weight affect the motion of a sailboat.

Suggested Grade Levels: 3-5

LESSON OBJECTIVES *Connecting to the Framework*

PHYSICAL SCIENCES

CORE IDEA PS1: MATTER AND ITS INTERACTIONS

PS1.A: STRUCTURE AND PROPERTIES OF MATTER

By the end of grade 5: Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means (e.g., by weighing or by its effects on other objects). For example, a model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon [and] the effects of air on larger particles or objects.

CORE IDEA PS3: ENERGY

PS3.C: RELATIONSHIPS BETWEEN ENERGY AND FORCES

By the end of grade 5: When objects collide, the contact forces transfer energy so as to change the objects' motions.

Featured Picture Books

TITLE: ***The Wind Blew***
AUTHOR: **Pat Hutchins**
ILLUSTRATOR: **Pat Hutchins**
PUBLISHER: **Aladdin**
YEAR: **1993**
GENRE: **Story**
SUMMARY: *Fanciful illustrations and rhyming text describe a day when the wind nearly blew an umbrella, kite, wig, and other items to the sea.*

TITLE: ***I Face the Wind***
AUTHOR: **Vicki Cobb**
ILLUSTRATOR: **Julia Gorton**
PUBLISHER: **HarperCollins**
YEAR: **2003**
GENRE: **Non-Narrative Information**
SUMMARY: *Simple, fun experiments help readers discover what wind is made of and why they can feel it.*

Time Needed

This lesson will take about a week. Suggested scheduling is as follows:

Day 1: **Engage** with *The Wind Blew* Read-Aloud and **Explore** with Wind Challenges

Day 2: **Explain** with *I Face the Wind* Read-Aloud and experiments

Day 3: **Elaborate** with *The Wind Blew* Checkpoint Lab, Parts A and B

Day 4: **Elaborate** with *The Wind Blew* Checkpoint Lab, Parts C and D

Day 5: **Evaluate** with *The Wind Blew* Checkpoint Lab Part E (Poster Session)

Materials

For Wind Challenges (per pair)

- Plastic handheld air pump
- Ping-Pong ball
- Measuring tape or meterstick
- Cup

For* I Face the Wind *Read-Aloud

Per class

- Wire coat hanger
- Pencil
- Two identical balloons or two gallon-size zippered plastic bags
- Tape

Per pair

- Large plastic grocery bag with no holes
- Small ball (a golf ball, racquetball, bouncy ball, or tennis ball will do)

NOTE: The Explore portion of this lesson is ideally done on tiled floors. If your classroom floors are carpeted, try to find other areas in your school that have smooth surfaced floors, such as the hallways, gymnasium, or cafeteria.

For* The Wind Blew *Checkpoint Lab (per four-person team)

Per class

- Heavy-duty aluminum foil (enough to make boats and to repair them if needed)
- Hole punch
- Sail cut-out and extra sails (in case students need to make repairs)
- Tape for securing sail to straw
- Masking tape for boat name
- Paper towels

Per four-person team

- Wallpaper trough (or other long, shallow container)
- Water for filling trough
- 3 plastic handheld air pumps

- Paper towels
- Soap bar box (or a box of similar size and weight) with the top removed
- Heavy-duty aluminum foil for covering box
- Straw for mast, cut to three-quarters of its length
- Clay for holding mast
- Paper towel
- 15 pennies for weight
- Timer
- Calculator
- Red cup and green cup, taped together
- Team Task Cards (precut)
- Markers
- Small zippered plastic bags to store clay

For Poster Session (per four-person team)

- Poster board or construction paper
- Markers

Student Pages

- Wind Challenges
- The Wind Blew Checkpoint Lab

Background

A Framework for K–12 Science Education suggests that the study of physical science in grades 3–5 be qualitative and conceptual in order to build a foundation for quantitative study in the middle school and high school years. This lesson addresses three core ideas in physical science in a conceptual and integrated manner: matter, energy, and forces and motion. Students learn through activities and reading that wind is moving air and that air is matter, even though you can't see it. Then, by using handheld air pumps to move a Ping-Pong ball, students learn that when matter (like air molecules) collides with another object, the contact force can change the motion of that object. Building on that idea, students experiment with a homemade sailboat to learn that forces have both a strength and direction. Manipulation of various objects develops students' understandings of the forces used to control position and movement.

In this lesson, students use moving air to control the distance and direction a ball travels and investigate how wind force affects the movement of a sailboat. They conduct simple experiments to prove that air is present, even though it can't be seen, and begin to understand that wind is composed of molecules that apply a push when they collide with objects. Their explorations reveal that an object's movement and speed are affected by the direction and strength of a force, as well as the mass of the object itself. Furthermore, when opposing forces are present, the greater of the forces will determine the direction an object travels.

Wind Challenges

engage

The Wind Blew Read-Aloud

Connecting to the Common Core
Reading: Literature
Key Ideas and Details: 3.1, 4.1, 5.1

Inferring

In advance, use paper to hide the cover of the book *The Wind Blew*, and don't tell students the title. Tell them you have a book to share and you want them to infer what is causing the events in the story, without seeing the pictures. When they think they know what "it" is, they can signal (e.g., raise hand or tug ear). When you begin reading aloud, skip the title page and first page of the story, which states, "The wind blew." Instead, begin reading on the next page. ("It took the umbrella from Mr. White and quickly turned it inside out.") Don't reveal the illustrations yet.

Continue reading the rest of the book, stopping after the last page to ask

? What do you think "it" is?

Ask students to whisper their inference to the person next to them. Then ask a few students to share with the entire class. Students will likely have decided the wind caused the events in the story. Reveal the cover of the book and then go back through it to show the illustrations.

Making Connections: Text-to-Self

Ask

? How did you know that the wind caused the events in the story? Could you see it? (Students may say that you can't see the wind, but you can feel it on your skin and see objects moving.)

? Have you ever had an experience with the wind like those in the book? (Have them turn and talk to a partner about their experiences.)

? How could we make our own wind in the classroom? Have several students share their suggestions. (Answers may include a fan, breath, or waving your hand.)

explore

Wind Challenges

Tell students that they are going to be creating their own wind by using a handheld air pump. Give each pair an air pump and have them take turns pumping the air lightly on their partner's hands. Explain that they will be using this method to complete some wind challenges on the floor with a Ping-Pong ball and a partner.

SAFETY

Be careful when working with balls or other equipment on the floor. They can be a serious trip/slip fall hazard. When working with projectiles, students should wear safety glasses or goggles.

Give each pair of students a Ping-Pong ball, measuring tape or meterstick, cup, and the Wind Challenges student page. Encourage teamwork as they complete the challenges on the student page using only the air from the pump:

- Can you make your ball roll more than 1 meter?
- Can you make your ball roll faster?
- Can you make your ball roll straight and then reverse directions?
- Can you make your ball roll into a cup that is lying on its side?
- Can you make your ball roll in a curved path?

Allow students several minutes to work on the challenges. Then bring them back together and *ask*

? How did you make your ball move more than 1 meter? (by positioning the pump behind the ball and pumping fast enough to make it move the distance)

? How did you make your ball roll faster? (by pumping faster)

? How did you make your ball roll straight and then reverse directions? (by pumping the air behind it and then in the opposite direction)

? How did you make your ball roll into a cup? (by positioning the pump directly behind the ball and in line with the cup, and by pumping fast enough to push the ball over the lip of the cup; students may also mention that a partner had to hold the cup in place so that the ball or air did not push it out of position)

? How did you make your ball roll in a curved path? (by pumping short pumps in a curve)

? Did your ball ever go in a direction you didn't mean for it to go? Why do you think this happened? (because the pump was not positioned at the correct angle for making it move in the desired direction)

explain

I Face the Wind Read-Aloud

Connecting to the Common Core
Reading: Informational Text
Key Ideas and Details: 3.3, 4.3, 5.3

Tell students that you have a nonfiction book to help them learn more about wind. Show students the cover of *I Face the Wind* and introduce the author.

NOTE: Author Vicki Cobb suggests that the best way to use her book is to do the activities described, without rushing, as they come up during the reading. Before you begin reading, make sure you have all the necessary supplies at hand. The author also suggests not turning the page to the explanation until after the child has made the discovery. That way, the book will reinforce what the child has discovered through experience. (See "Note to the Reader" in *I Face the Wind*.)

STOP and TRY IT

While reading aloud *I Face the Wind,* pause where noted to ask questions and try the activities.

First, read aloud pages 1–12.

STOP

After reading page 12, ask

? What is wind made of? (air)

TRY IT

Demonstrate how to trap air inside a plastic grocery bag by pulling the opened bag quickly through the air and twisting the ends closed. Tell the students to try this with a partner. Give each pair a plastic bag with no holes. Caution them not to squeeze their bags hard enough to pop them. Once every student has tried it once, ask the pairs to fill their bags again, twist them closed and hold them. *Ask*

? What will happen if we open the bag? (Some of the air will come out of the bag and into the room.)

Tell everyone to open the bag and hold it open. *Ask*

? If the bag is open, is air still in the bag? (Yes, air is in the bag and in the room, even if we can't see it.)

Collect the bags and continue reading pages 13–18.

SAFETY

When working with plastic bags or balloons, remind students to keep them away from their mouths. These are potential breathing and/or choking hazards.

Trapping Air in a Plastic Bag

STOP

Stop after you read page 18, which asks, “What happens when you hang it [the hanger] on the pencil?” Ask the students to predict what will happen when you hang a hanger holding both the inflated and the noninflated balloons.

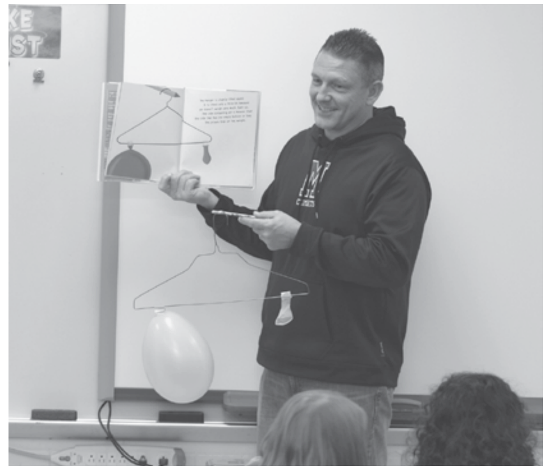
TRY IT

Set up the demonstration as instructed by the book with two balloons taped to a hanger. Hook the hanger over a pencil with the two deflated balloons positioned so the hanger is balanced. *Ask*

? Why is the hanger balanced? (The balloons both weigh the same.)

Fill one of the balloons with air, tie it off, and attach it in the same place. *Ask*

? What do you notice about the hanger? (It is tilted, with the inflated balloon hanging lower than the other balloon.)



Demonstrating That Air Has Weight

? Why do you think the inflated balloon is hanging lower? (It is heavier because it contains more air.)

? This proves that air has what? (weight or mass)

Continue reading pages 19–24.

STOP

After reading page 24, *ask*

? Which would make a stronger bump, a fast-moving ball or a slow-moving ball?

TRY IT

Give each pair of students a ball and allow them to try the activity described on pages 23 and 24. *Ask*

? Which made a stronger bump, rolling it quickly or slowly? (Rolling it quickly made a stronger bump.)

Explain that in this activity the ball is being used as a model of moving air. The faster the ball moves, the stronger the bump. The faster air molecules move, the more force they are able to apply. A force is a push or pull. You can feel wind because the air molecules are pushing on you.

Read pages 25 and 26.

STOP

After reading page 26, *ask*

? Do you think the wind would be stronger if I wave a book slowly or quickly?

TRY IT

Wave a book slowly and then quickly as you walk around students. *Ask*

? Why is the wind stronger when I wave the book quickly? (The air molecules move faster, causing a stronger push on you, just as rolling the ball more quickly caused a stronger bump.)

Read the rest of the book aloud.

SAFETY

Be careful to quickly wipe up any spilled water on the floor. This is a slip/fall hazard which can result in serious injury.

elaborate

The Wind Blew Checkpoint Lab

In advance, prepare the supplies for the checkpoint lab. See Chapter 3, "Teaching Science Though Inquiry," for a list of tips for managing a checkpoint lab.

1. Cut the tops from the soap bar boxes and reinforce the corners with tape.
2. Cut the straws for the mast to three-quarters of their length. If using bendable straws, cut the straw beneath the bendable section.
3. Tear pieces of foil large enough to cover the box.
4. Fill the wallpaper troughs with water and place them around the room. If you are using a trough with ridges on the inside, be sure to fill the container about three-quarters full to avoid having the boat get stuck.
5. Place the following supplies in a central location for collection and use as needed:
   - Heavy-duty aluminum foil (enough to make boats and to repair them if needed)
   - Hole punch
   - Sail cut-out and extra sails (in case students need to make repairs)
   - Tape for securing sail to straw
   - Piece of masking tape for boat name
   - Paper towels
6. Place the following supplies in a container or bucket for easy collection by each group:
   - 3 air pumps
   - Soap bar box
   - Straw for mast, cut to three-quarters of its length
   - Lump of clay for holding mast
   - Paper towel
   - 15 pennies for weight
   - Timer
   - Calculator
   - Red cup and green cup, taped together
   - Markers
   - Small zippered bags to store clay
7. At the end of each day, have the students remove the clay from their boats and place the clay in a zippered bag to prevent drying.

Tell students that they will be investigating how wind force affects the motion of a boat. Divide students into four-person teams. Give all students a copy of The Wind Blew Checkpoint Lab student page and explain that they will be following the directions to build a sailboat and complete the lab.

Give students the following instructions: "Scientists do the same experiment several times to make sure their results are accurate. You will complete a few trials for each setup. Your results are unlikely to be the same for every trial. Scientists call this variability. You will take an average to determine the time it takes the boat to travel. Ideally, you would repeat the experiments over and over, but due to our time constraints, we will repeat them only three times." Explain how to calculate an average. (Add up the times of all trials, and then divide by the number of trials.)

Give each team member a Team Task Card. Tell students that they may rotate cards on subsequent days.

- The Reader reads the directions as the group is working and is in charge of the green and red cups.
- The Wind Maker uses the pump to create wind to move the boat and chooses a second Wind Maker when necessary.
- The Boat Handler makes changes to the boat, places it in and out of the water, and says "Ready, set, sail!"
- The Materials Manager collects and returns all materials and uses the timer and calculator.

Allow the students to collect their supplies and begin the lab. Check their progress and give assistance when necessary. Each member of the group is responsible for recording data and responses. Before you give a team a check mark or stamp to move forward in the lab, informally evaluate the students by asking probing questions to different members of the team, such as

- How do you know?
- What is your evidence?
- Are you surprised by the results? Why or why not?
- What do you think will happen next?

Redirect their investigations when necessary. As they are working, they should keep the green cup on top of the red cup. If they need help or reach a checkpoint, they should reverse the cups so that the red one is on top.

Checkpoint Lab

evaluate

Poster Session

Writing

Connecting to the Common Core
Writing
Text Types and Purposes: 3.2, 4.2, 5.2

Teams that have completed parts A through D of *The Wind Blew* Checkpoint Lab should begin the Poster Session (part E). Explain that scientists and engineers routinely hold poster sessions to communicate their findings to other professionals in their field. Each member of a team will be responsible for creating one section of a poster that communicates the findings from one part of the checkpoint lab (A, B, C, or D). Tell students to use the 3-point rubric in part E to guide their work:

- 3 points for a detailed description of your part of the lab, including a labeled diagram
- 2 points for a conclusion based on evidence
- 1 point for a clear explanation presented to the audience

Connecting to the Common Core
Speaking and Listening
Presentation of Knowledge and Ideas: 3.4, 4.4, 5.4

After all teams have completed their posters, have each team member briefly explain their section of their team's poster. Remind them to speak clearly and at an understandable pace. Encourage the audience to ask questions and provide feedback to the presenters in a polite, respectful manner. Audience members can identify similarities to and differences from their own findings, point out faulty reasoning, and suggest alternative explanations.

After all teams have presented, summarize the concepts the students have investigated in each part of the checkpoint lab. The following explanations of each part of the checkpoint lab are for you. Modify them as necessary to help students understand and apply the concepts.

PART A: Students will discover that the force of their wind moves the boat from one end of the waterway to the other. Greater wind force can move the boat more quickly, but it may also make the boat unsteady, causing it to turn or spin. Students may also discover that the boat slows down as it moves away from them. The sail's ability to "catch" the wind decreases as the air spreads out. Pumping faster will help them compensate for this, as the faster-moving air molecules apply a greater force to the sail. Pumping air toward one side of the sail more than the other will cause the boat to turn. Pumping air on the right will produce a turn to the left, whereas pumping air on the left will produce a turn to the right. Other forces may also contribute to the motion of the boat, such as ridges along the waterway, which may cause the boat to become stuck.

PART B: When two students use the air pumps, more moving air molecules make contact with the sail, pushing it forward more quickly than the force of a single air pump. The boat's speed increases with greater wind force. Some groups may find that the force of two air pumps blowing causes the boat to become unstable. With two Wind Makers, one person may pump faster on a single side of the sail than the other, causing the boat to turn or spin.

PART C: Students are likely to observe that the boat slows down or moves backward when there is an opposing wind force. In the case of two students pumping air in the opposite direction of one, the boat is likely to move in the direction the two air pumps are blowing, at least for a while. When two forces oppose one another, the greater of the two forces will determine the direction of the boat. Distance from the wind force also plays a role. As the boat moves away from one wind force, it is likely to reverse directions as it approaches the opposing wind force.

PART D: If the same force is applied, the speed of a boat will decrease as its weight increases. Heavier objects have greater inertia, a resistance to a change in motion. A greater force is necessary to move these objects. For example, it is easy to move a toy car forward. It takes much greater force to move a real car forward. With the addition of a load, the boat has greater inertia and takes longer to begin moving when a force is applied. For this lesson, it is not important to introduce the concept of inertia unless you desire to do so. The goal is for students to recognize that increased weight affects the boat's ability to move.

After this discussion, give students the opportunity to make changes to their posters before you grade them using the 3-point rubric.

Websites

KidWind Project
www.kidwind.org
Access ideas, lessons, and science fair projects for teaching your students about wind energy.

PBS Kids DragonflyTV "Sailboat"
http://pbskids.org/dragonflytv/show/sailboat.html
Watch a video about two boys who try to discover which sailboat is faster, a double-hull catamaran or a single-hull Lido. The boys build models of their boats to test variables such as sail size, mass, and drag. Then they step inside their boats to have an actual race. Will real life produce the same results?

PBS Kids DragonflyTV "Dragonfly TV Cup"
http://pbskids.org/dragonflytv/games/game_sailing.html
Students play a game in which they adjust the direction and sail position of a virtual boat to navigate a course.

More Books to Read

Branley, F. M. *Air is all around you.* 2006. New York: HarperCollins.

Inquiry Place

Have students brainstorm questions about wind. Examples of such questions include

- ? What causes wind? Research it!
- ? What places on Earth experience more wind than our location? Why? Research it!
- ? How is wind used for energy? Research it!
- ? Does changing the size of a sail affect the motion of a sailboat? Test it!
- ? Does changing the shape of a sail affect the motion of a sailboat? Test it!

Then have students select a question to research or investigate as a class, or have groups of students vote on the question they want to research or investigate as a team. After they make predictions, have them design an experiment to test their predictions. Students can present their findings at a poster session or gallery walk.

Summary: Even though you can't see it, air is everywhere. Interesting facts and simple experiments describe the concept of air and its importance to our world.

Derby, S. *Whoosh went the wind.* 2006. New York: Marshall Cavendish Children.
Summary: A young boy is late for school, and it's all because of the wind! The teacher doubts his outlandish claims, but discovers he's telling the truth when the wind sweeps her out of the classroom window.

Dorros, A. *Feel the wind.* 1990. New York: HarperCollins.
Summary: Simple text and fun facts describe what makes the wind and how it affects the weather. Directions for making a weather vane are also provided.

Name: ______________________________

Wind Challenges

Can you do the challenges below using only your air pump and a Ping-Pong ball?

1. Can you make your ball roll more than one meter?

☐ yes ☐ no

2. Can you make your ball roll faster?

☐ yes ☐ no

3. Can you make your ball roll straight and then reverse directions?

☐ yes ☐ no

4. Can you make your ball roll into a cup that is lying on its side?

☐ yes ☐ no

5. Can you make your ball roll in a curved path?

☐ yes ☐ no

The Wind Blew

Team Task Cards

Reader

Read the directions out loud for your team. Put the green cup on top if your group is working. Put the red cup on top if you have a question or if you are ready for a check mark.

Wind Maker

Wait until you hear the directions from the Reader. Then use the air pump to blow on the sail. Keep your pump behind the starting line. Choose a second or third Wind Maker when necessary.

Boat Handler

Wait until you hear the directions from the Reader. Then make changes to the boat if needed. Place the boat in the water. Say, "Ready, set, sail!" Remove the boat when it's not in use.

Materials Manager

Collect all materials. Also use the timer and calculator when needed. When your group receives a check mark, return all materials and have your team help you clean up your workspace.

Name: ____

The Wind Blew

Checkpoint Lab

Follow the directions below. If your team is working, put the green cup on top. If you have a question, put the red cup on top. If you are finished with a part and you are ready for a check from your teacher, put the red cup on top.

Building Your Sailboat

Check the boxes ☑ as your team completes each step.

- ☐ Place the box in the center of your foil. Gently wrap the foil over the sides and into the center of the box. If the foil tears, get a new piece.
- ☐ Place a small lump of clay in the center inside of the boat.
- ☐ Cut out the sail. Use a hole-punch to cut the two circles on the sail.
- ☐ Thread the straw through the two holes in the sail.
- ☐ Put one end of the straw in the clay. Your straw should stand straight up.

Checkpoint Lab *continued*

The Wind Blew

☐ Slide the sail down so that the bottom edge touches the top of the boat.

☐ Tape the sail to the straw so that the sail is curved.

☐ Think of a name for your boat. Write it on a piece of masking tape and put it on the back of your boat.

How to Protect Your Boat

- If you notice water inside your boat, signal your teacher for help. You may have a leak and need new foil.
- Remove your boat from the waterway and place it on a paper towel when not in use.
- Remove the clay from the straw and boat at the end of every day and place it in a plastic zippered bag. This will keep it from drying out.

Part A

Set Sail!

Throughout this lab, you will be using your air pump to create wind to move the sailboat across a waterway.

- Place the sailboat at one end of the waterway. This will be your starting line.
- Pump air directly toward the boat's sail, but do not allow your pump to pass the starting line at any time. Try to make the boat move to the other end of the waterway.

1. What force caused the sailboat to move across the water?

- Place the sailboat at the starting line.
- This time, pump the air harder on the sail, but do not allow your pump to pass the starting line.

2. Compare the motion of the sailboat to the first time you did this.

- Place the sailboat at the starting line.
- Pump air on the right side of the sail.

Part A *continued*

Set Sail!

3. Which direction does the boat move (right or left)?

___

- Place the sailboat at the starting line again.
- Now pump air on the left side of the sail.

4. Which direction does the boat move (right or left)?

___

5. Write a conclusion. How does the direction of the wind force affect the direction the boat moves?

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☐ **Checkpoint A**

Part B

Changing the Amount of Wind

Place the sailboat at the starting line.

- Pump air directly toward the boat's sail, but do not allow your pump to pass the starting line of the waterway.
- Have one team member say, "Ready, set, sail!" On "sail," start the timer as the Wind Maker begins pumping.
- Stop the timer when the sailboat touches the other end of the waterway. Record the time under Trial 1 Time.
- Repeat for Trial 2 and Trial 3.
- Find the average time it took the sailboat to move by adding the three times and dividing by 3.

Number of Wind Makers	Trial 1 Time	Trial 2 Time	Trial 3 Time	Average Time
1				

Make a prediction: If you add another Wind Maker to pump air on the sail, will the boat take a longer or shorter amount of time to move to the other end?

Part B *continued*

Changing the Amount of Wind

- Place the sailboat at the starting line.
- Now add a second Wind Maker so that two people will be pumping air toward the sail.
- Pump directly toward the boat's sail. Do not allow your pumps to pass the starting line of the waterway.
- Have one team member say, "Ready, set, sail!" On "sail," start the timer as the Wind Makers begin pumping.
- Stop the timer when the sailboat touches the other end of the waterway. Record the time under Trial 1 Time.
- Repeat for Trial 2 and Trial 3.
- Find the average time it took the sailboat to move by adding the three times and dividing by 3.

Number of Wind Makers	Trial 1 Time	Trial 2 Time	Trial 3 Time	Average Time
2				

Part B *continued*

Changing the Amount of Wind

1. What was the average time the sailboat moved with one Wind Maker? ______________________________

2. What was the average time the sailboat moved with two WindMakers?______________________________

3. Did the sailboat take a longer or shorter amount of time to cross the waterway when you added a second Wind Maker?

____

4. Write a conclusion: How does the amount of wind affect the speed of the sailboat?

____

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☐ **Checkpoint B**

Part C
Opposing Winds

- Place the sailboat at the starting line.
- One Wind Maker should sit at the starting line and another Wind Maker should sit at the other end.
- The pumps should not be allowed to pass the end of the waterway at any time.
- Each person will pump directly toward the boat's sail for 10 seconds. The winds will oppose one another.
- Make a prediction: What will happen when both Wind Makers pump air against the sail?________________________________

____

- Have one team member say, "Ready, set, sail!" On "sail," start the timer as the opposing Wind Makers begin pumping air.
- After 10 seconds, say "Stop."

Describe the motion of the sailboat.

____

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Explain why you think the sailboat moved this way.

____

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Part C *continued*

Opposing Winds

- Now place the sailboat at the starting line again.
- Two Wind Makers should sit at the starting line and one Wind Maker should sit at the other end.
- Each person will pump directly toward the boat's sail for 10 seconds.
- The pumps should not be allowed to pass the end of the waterway at any time.
- Make a prediction: What will happen when two Wind Makers pump air from the starting end of the waterway and one Wind Maker pumps air from the other end?

____

____

____

- Have one team member say, "Ready, set, sail!" On "sail," start the timer as all Wind Makers begin pumping air.
- After 10 seconds, say "Stop."

Describe the motion of the sailboat. ________________________

____

Explain why you think the sailboat moved this way.

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☐ **Checkpoint C**

Part D

Increasing the Weight of the Sailboat

- Place the sailboat at the starting line.
- Pump air directly toward the boat's sail, but do not allow your pump to pass the starting line of the waterway.
- Have one team member say, "Ready, set, sail!" On "sail," start the timer as the Wind Maker begins pumping.
- Stop the timer when the sailboat touches the other end of the waterway. Record the time under Trial 1 Time.
- Repeat for Trial 2 and Trial 3.
- Find the average time it took the sailboat to move by adding the three times and dividing by 3.

Number of Pennies	Trial 1 Time	Trial 2 Time	Trial 3 Time	Average Time
0				

Make a prediction: If you place 15 pennies inside the boat, will it take a longer or shorter amount of time to move to the other end?

____

____

____

- Now put 15 pennies inside the boat and place it at the starting line.
- Remember to keep your pump behind the starting line at all times.
- Have one team member say, "Ready, set, sail!" On "sail," start the timer as the Wind Maker begins pumping.
- Stop the timer when the sailboat touches the other end of the waterway. Record the time under Trial 1 Time.
- Repeat for Trial 2 and Trial 3.
- Find the average time it took the sailboat to move by adding the three times and dividing by 3.

Number of Pennies	Trial 1 Time	Trial 2 Time	Trial 3 Time	Average Time
15				

1. What was the average time the sailboat moved with zero pennies?____________________

2. What was the average time the sailboat moved with 15 pennies? ____________________

3. Did the sailboat take a longer or shorter amount of time to cross the waterway when you added 15 pennies?

____

4. Write a conclusion: How does the weight of the sailboat affect its speed?

____

____

____

☐ **Checkpoint D**

Part E

Poster Session

Make a poster with your team displaying what you learned about wind forces and motion from The Wind Blew lab. Each member of your team should choose a different part of the lab. Label your section with Part A, Part B, Part C, or Part D.

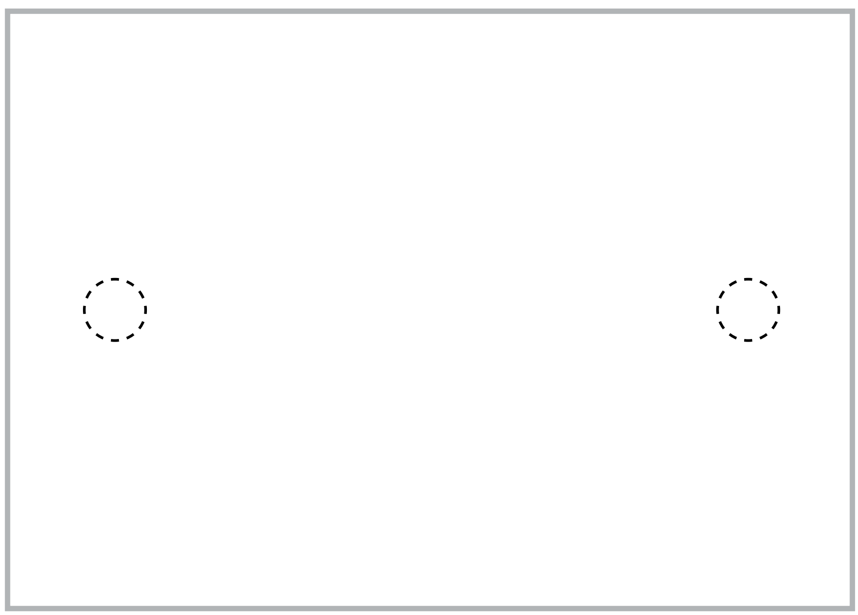
Here are some things teams should include in each part (A, B, C, and D) of the poster:

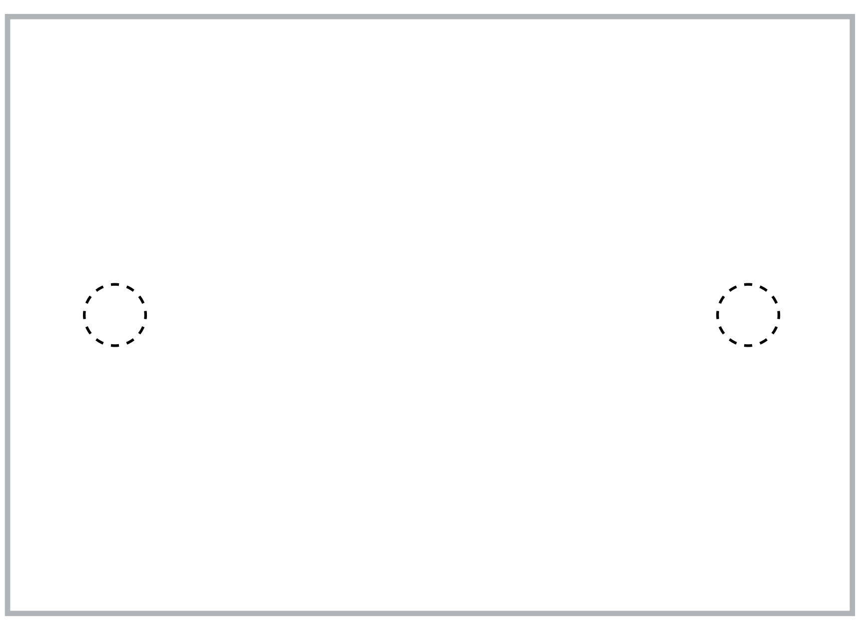
3 Points: A detailed description of your part of the lab—A, B, C, or D, including a labeled diagram

2 Points: A conclusion based on evidence (What did you learn about wind forces and motion?)

1 Point: A clear explanation presented to the audience. Be ready to share your poster with the class and answer any questions they might have.

Sail Cutouts





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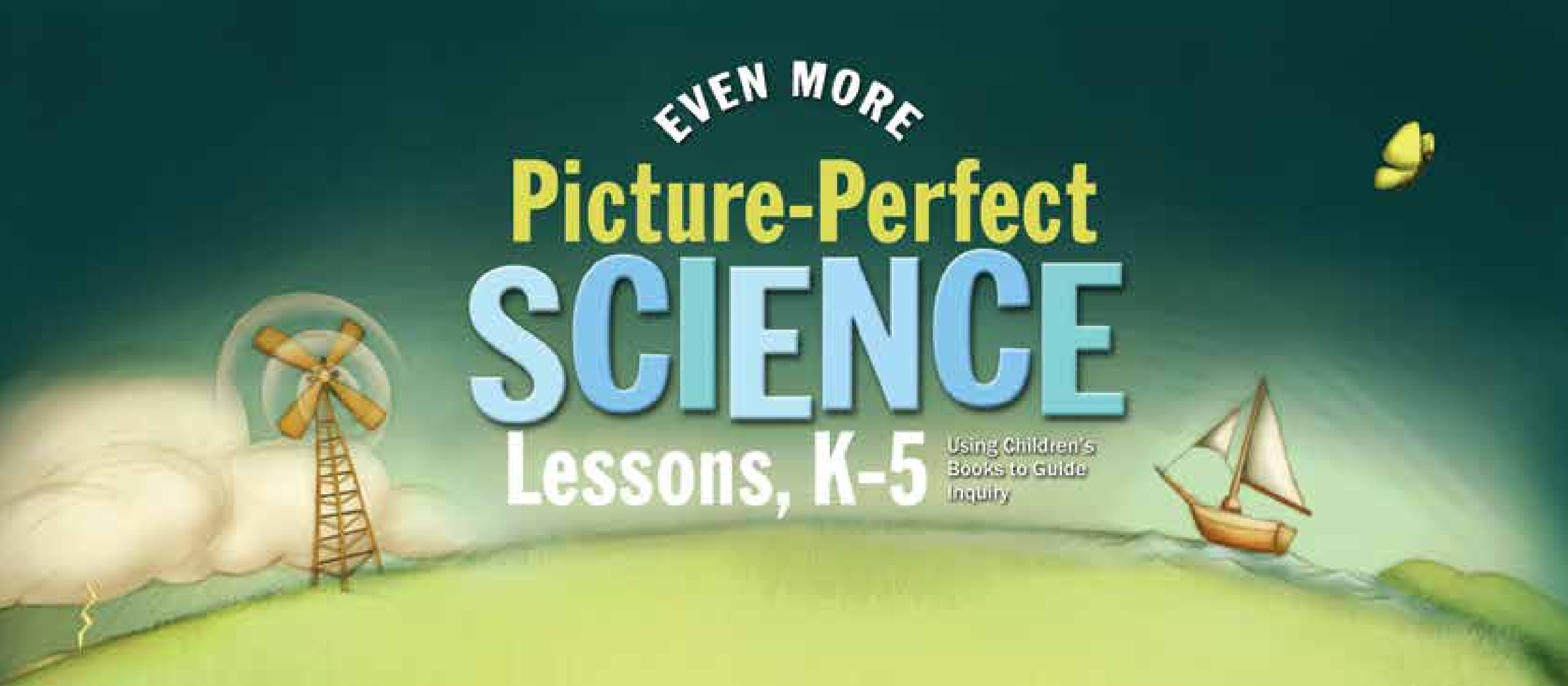

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