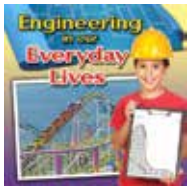
Every Part Has a Purpose

By Emily Morgan and Karen Ansberry

As students put on their backpacks at the end of the day, they probably do not stop to ponder how each part works together to hold and transport school materials. Students don't give a second thought to the purpose of the laces and rubber soles of their shoes as they exercise in gym class. Drawing students' attention to how each part of an object contributes to the whole can set the foundation for teaching an important science concept. In this month's lessons, students explore the structure and function of designed objects, introducing them to the world of engineering.

This Month's Trade Books



Engineering in Our Everyday Lives
By Reagan Miller
Crabtree Publishing. 2014.
ISBN: 978-0-7787-0099-9
Grades K–2

Synopsis

Simple text and photographs explain what engineers do and how engineering affects our everyday lives.

Rosie Revere, Engineer
By Andrea Beaty
Illustrated by David Roberts
Abrams Books for Young Readers. 2013.
ISBN: 978-1-4197-0845-9
Grades 3–5

Synopsis

Young Rosie dreams of being an engineer. Alone in her room at night, she constructs great inventions from odds and ends. Afraid of failure, Rosie hides her creations under her bed until a fateful visit from her great-great-aunt Rose, who shows her that a first flop isn't something to fear—it's something to celebrate.

Curricular Connections

The *Next Generation Science Standards* identifies Structure and Function as one of the crosscutting concepts that progresses across all grade levels. In grades K–2, the *NGSS* suggest that, "students observe that the shape and stability of natural and designed objects are related to their functions" (Appendix G, NGSS Lead States 2013, p. 87). In this month's K–2 activity, students learn about what engineers do, discuss the structures and functions of a backpack, and then come up with a structure to add to a backpack that serves a specific function.

The crosscutting concept of Structure and Function progresses in grades 3–5. Specifically, "students will understand that different materials have different substructures, which can sometimes be observed, and substructures have shapes and parts that serve functions" (Appendix G, NGSS Lead States 2013, p. 87). In the 3–5 lesson, after reading a story about how first flops in inventing should be motivating rather than discouraging, students take apart simple designed objects and discuss the structure and function of various parts. Next they use these parts to invent something useful, testing it and improving it. ■

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Reference

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

Grades K–2: Build a Better Backpack

Purpose

Students learn that engineers design objects that people use every day, including backpacks. They identify the structures and functions of the parts on a backpack and then design a "new-and-improved" backpack.

Engage

Tell students that you have a problem you need help with. Show them all of the papers, books, pencils, keys, water bottles, and so on that you need to bring to and from school, and tell them that you are having trouble keeping them organized. The stacks of paper slide around in your car, you lose the small items, and things keep getting mixed up. Ask them what they recommend you use to keep this from happening. Students might suggest you carry these items in a bag or backpack. Bring out a backpack and discuss the various compartments and where you should place each item (e.g., the best place to put a pencil, what compartment should hold the books, what part might be best to hold a water bottle, and so on).

Explore

Ask students to examine the backpack and name as many parts as they can (e.g., straps, zippers, pockets). As they identify each part, ask students to explain the purpose of that part. Create a T-chart on the board with "Part" over the left column and "Purpose" over the right column. (You will change these titles later when vocabulary is introduced in the explain phase of this lesson.)

Materials

- Backpack
- Art supplies

Example:

Backpack

Part	Purpose
Straps	To hold it on your back
Zipper	To keep things inside
Mesh side pocket	To hold a water bottle
Small outside zipper pocket	To hold small items

Next, ask students,

- Where do backpacks come from? (a store)
- Where do you think a store gets backpacks? (from a factory)
- Where might a factory get the instructions to make a backpack? (Allow them to share their ideas. Then, explain that a person or team of people, called engineers, design things like backpacks and all of their parts.)

Explain

Show students the cover of *Engineering in Our Everyday Lives*. Tell students that this book is about people who design objects we use every day, like backpacks. Read the book aloud, stopping to ask the questions on the insets to assess their comprehension of the corresponding pages (CC ELA Connection: Reading: Informational Text – Key Ideas and Details). Revisit pages 6–7 of the book,

which explain that something that is created by engineers to solve a problem is called a technology. Point out the different technologies featured on those pages: a pencil, a computer, a soccer ball, and a backpack. Explain that when engineers design a technology, such as a backpack, they design it with specific *structures* (or parts) that serve specific *functions* (or purposes). Revisit your T-chart and ask students which side could be labeled "Structure" and which could be labeled "Function." They should recognize that the left-hand "Part" column could be changed to "Structure" and the right-hand "Purpose" column could be changed to "Function" in order to model the vocabulary that engineers use in their jobs (CC ELA Connection: Language Standards: Vocabulary Acquisition and Use).

Elaborate

Revisit pages 12–15, which explain that engineers are always trying to improve technologies in different ways. Then read the section called "Your turn," which challenges students to think about how they might improve an everyday object to make it work better or do something it cannot do now. Tell students that you would like them to improve a backpack. Have them follow the steps listed on page 15:

- *Make a list of ideas of how you could improve the object.*
- *Choose your favorite idea. Draw a picture of your object or tool.*
- *Explain how your changes make the object or tool better and more useful to people.*

As an example, show them "My Improved Bicycle" on page 15. Ask them to identify the new structure on the Rain-or-Shine Rider (an umbrella) and its function (to keep the rider dry or in the shade) (CC ELA Connection: Reading: Informational Text – Integration of Knowledge and Ideas).

Evaluate

Have students create a poster advertising their improved backpack, which includes the following criteria (CC ELA Connection: Writing):

- Name of the "new-and-improved" backpack,
- A labeled diagram showing its new structure,
- A T-chart listing the new structure and its function,
- An explanation of why this new-and-improved backpack is better than the original,
- Extra Credit: Create a song, rap, or slogan to sell the new backpack.

Grades 3–5: Take Apart and Repurpose

Purpose

Students learn about the relationship between structure and function of designed objects by taking apart various devices and designing their own inventions out of the parts they uncover.

Engage

Show students the cover of *Rosie Revere, Engineer*. Ask them if they know what an engineer does. Have them share their ideas. Tell students that engineers are people who design things to solve problems. Tell students that as you read, you would like them to listen for things that show how Rosie is an engineer (CC ELA Connection: Literature – Key Ideas and Details). Read the story aloud. After reading, ask, "How is Rosie an engineer?" Students should recognize that Rosie takes things apart, builds things to solve problems, and tests her inventions. All of these are things that engineers do. Open the book to pages 6–7, which shows Rosie's attic. Ask students where Rosie gets all of the materials she uses to create new gadgets and gizmos. They should recognize from the illustrations that Rosie gets her parts from machines, appliances, and toys that people throw away (CC ELA Connection: Literature – Integration of Knowledge and Ideas). Tell students that, like Rosie, they are going to take apart some old devices to reveal the parts inside. You will need to collect some devices so that you have one for each pair of students. (See the materials and safety sections for some ideas and important safety information.)

Safety

CAUTION

When choosing devices to take apart, be sure they do not contain any sharp or hazardous materials, such as powerful magnets or glass tubes.

1. If disassembling any devices with electrical cords, be sure the cords are cut off before taking the devices apart.
2. Students should wear safety glasses or goggles.
3. If screwdrivers are needed, direct adult supervision of students working with screwdrivers is highly recommended.
4. Remind students that sharp objects, including metal and plastic objects, can cut skin.

Materials

- Small sticky note pads (one per pair)
- Art supplies
- Simple designed objects made of several parts (one per pair), such as:
  - ◊ Toy
  - ◊ Ballpoint clicker pen
  - ◊ Tape dispenser
  - ◊ Battery-operated clock
  - ◊ Flashlight
  - ◊ Stapler

Explore

Give each student a pair of safety goggles. Then, give each pair of students a device to take apart. First, have students discuss what their device does and what they think might be inside. Then allow students to open up their device. (Depending on the age of your students and the type of devices they are taking apart, you may consider having parent volunteers come in to help disassemble the devices.) Have students use small sticky notes to label any parts that they think they recognize and allow them time to discuss how these parts help the device serve its purpose.

Explain

Tell students that all of these devices can be referred to as *designed objects* because they were each designed by engineers. Explain that designed objects are typically made up of various parts, or structures, and that each structure serves a specific function that relates to the overall function of the device. Explain that a *structure* means a specific part of something and *function* means the purpose that it serves. Use a simple designed object, such as a ballpoint pen, as an example. Show students the object and record

its name and function. As you take it apart, make a T-chart on the board and list various structures you found and their functions (CC ELA Connection: Vocabulary Acquisition and Use).

Example:

Designed Object: Ballpoint Clicker Pen

Function of the Device: Writing

Structure	Function
Clicker	Makes the pen go in and out
Spring	Makes the pen spring back into place when clicked
Plastic casing	Holds all of the parts
Ink tube	Contains the ink
Clip	Clips onto your pocket or papers
Plastic tip	Keeps the point steady as you are writing

Have students make their own Structure and Function T-chart for the designed object that they took apart. Have them list some structures on the left-hand side of the T-chart and list some possible functions of each structure on the corresponding right-hand side of the T-chart. It is not important that students correctly name the structures or identify the precise functions of each part, the purpose of this activity is to realize that each structure on a designed object is there to serve a specific function, and that it is the work of engineers to design these structures to serve specific functions so that the object does what it is supposed to do. To give students more background on what engineers do, you may want to show them the video "Intro to Engineering" from NASA for Kids (see Internet Resource).

Elaborate

Reread *Rosie Revere, Engineer*, stopping to look closely at some of the contraptions that she invents. Have students identify specific structures in her inventions and explain their functions (CC ELA Connection: Literature – Integration of Knowledge and Ideas). For example, on pages 10–11, ribbons are a structure that she uses for the function of tying the device onto her head. A string and a doll's leg are two structures she uses for the function of making the cheese spray come out of the can. After looking at several of Rosie's examples, challenge students to make something useful out of some of the parts from the designed objects they disassembled. Pairs may trade parts with other teams, and you may want to have some other disassembled objects so that students have a variety of parts from which to choose. They should give their device a name, describe its purpose, and create a T-chart listing each structure they used and its specific function (CC ELA Connection: Writing).

Evaluate

Refer back to the part of the story in which Rosie feels discouraged because her flying machine didn't work (pages 18–21), but her great-great-aunt Rose tells her, "Your brilliant first flop was a raging success! Come on, let's get busy and on to the next!" Explain that an important part of engineering is dealing with failures and learning from them. Then read the last line of page 27, "Life might have its failures, but this was not it. The only true failure can come if you quit." Explain that engineers often try many designs before they find one that works best, and that to be a good engineer you must persevere through failed attempts. Failures give engineers a chance to go back and improve on their original idea until they solve the problem. Encourage students to test and refine the device they invented. Finally, when they are happy with their design, have them share their new invention with the class through a presentation, commercial, or poster display. In their presentation they should include (CC ELA Connection: Speaking and Listening – Presentation of Knowledge and Ideas):

- the name of the device,
- a description of what it does,
- a T-chart showing all of the structures used and their functions, and
- a description of how they tested and improved it.

Internet Resource

NASA for Kids: Intro to Engineering
http://education.nationalgeographic.com/education/media/nasa-kids-intro-engineering/?ar_a=1

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

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

English/Language Arts

Reading Standards for Informational Text K–2: Integration of Knowledge and Ideas:

- CCSS.ELA-LITERACY.RI.K.7: With prompting and support, describe the relationship between illustrations and the text in which they appear (e.g., what person, place, thing, or idea in the text an illustration depicts).
- CCSS.ELA-LITERACY.RI.1.7: Use the illustrations and details in a text to describe its key ideas.
- CCSS.ELA-LITERACY.RI.2.7: Explain how specific images (e.g., a diagram showing how a machine works) contribute to and clarify a text.

Reading Standards for Informational Text K–2: Key Ideas and Details:

- CCSS.ELA-LITERACY.RI.K.1: With prompting and support, ask and answer questions to demonstrate understanding of a text.
- CCSS.ELA-LITERACY.RI.1.1: Ask and answer questions to demonstrate understanding of a text.
- CCSS.ELA-LITERACY.RI.2.1: Ask and answer questions such questions as who, what, when, where, why, and how to demonstrate understanding of key details in a text.

Language Standards K–2: Vocabulary Acquisition and Use

- CCSS.ELA-LITERACY.L.K.6: Use words and phrases acquired through conversations, reading and being read to, and responding to texts.
- CCSS.ELA-LITERACY.L.1.6: Use words and phrases acquired through conversations, reading and being read to, and responding to texts, including using conjunctions to signal simple relationships.
- CCSS.ELA-LITERACY.L.2.6: Use words and phrases acquired through conversations, reading and being read to, and responding to texts, including using adjectives and adverbs to describe.

Reading Standards for Literature 3–5: Key Ideas and Details:

- CCSS.ELA-LITERACY.RI.3.1: Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.
- CCSS.ELA-LITERACY.RI.4.1: Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.
- CCSS.ELA-LITERACY.RI.5.1: Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

Reading Standards for Literature 3–5: Integration of Knowledge and Ideas:

- CCSS.ELA-LITERACY.RL.3.7: Explain how specific aspects of a text's illustrations contribute to what is conveyed by the words in a story.

Language Standards 3–5: Vocabulary Acquisition and Use:

- CCSS.ELA-LITERACY.L.3.6: Acquire and use accurately grade-appropriate conversational, general academic, and domain-specific words and phrases.
- CCSS.ELA-LITERACY.L.4.6: Acquire and use accurately grade-appropriate conversational, general academic, and domain-specific words and phrases.
- CCSS.ELA-LITERACY.L.5.6: Acquire and use accurately grade-appropriate conversational, general academic, and domain-specific words and phrases.

Speaking and Listening Standards 3–5: Presentation of Knowledge and Ideas:

- CCSS.ELA-LITERACY.SL.3.4: Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.
- CCSS.ELA-LITERACY.SL.4.4: Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant descriptive details to support main ideas or themes; speak clearly at an understandable pace.
- CCSS.ELA-LITERACY.SL.5.4: Report on a topic or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

Writing across all content areas is emphasized within the Common Core, as seen by standard statement 10, which begins in grade 3 and states that students should "write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

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.

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

Grades K–2 K-2-ETS1 Engineering Design *www.nextgenscience.org/k-2ets1-engineering-design*	
Performance Expectation *The materials/lessons/activities outlined in this article are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required.*	**Connections to Classroom Activity**
K-2-ETS1-2 Develop a simple sketch, drawing or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.	Students develop a sketch to illustrate a new structure on a "new-and-improved" backpack and its function.
Science and Engineering Practice	
Developing and Using Models	Students develop a sketch to show a new structure for a backpack that serves a function that makes the "new-and-improved" backpack better than the original.
Disciplinary Core Idea	
ETS1.B. Developing Possible Solutions • Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.	Students use a sketch/drawing to communicate ideas for a "new-and-improved" backpack to others.
Crosscutting Concept	
Structure and Function	Students identify the structures on a backpack and their functions. Then, they design a "new-and-improved" backpack with a new structure that serves a different function.
Grades 3–5 3-5-ETS1 Engineering Design *www.nextgenscience.org/3-5ets1-engineering-design*	
Performance Expectation *see above.*	**Connections to Classroom Activity**
3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify different aspects of a model or prototype that can be improved.	Students test and improve prototypes that they develop out of repurposed parts of an old device or appliance.
Science and Engineering Practice	
Planning and Carrying Out Investigations	Students plan simple investigations to test the usefulness of a prototype they develop for a new or improved device.
Disciplinary Core Idea	
ETS1.C Optimizing the Design Solution • Tests are often designed to identify failure points or difficulties, which suggest the elements of a design that need to be improved.	Students hear a story that demonstrates that testing, failing, and improving are part of engineering. Students design a useful device then test and improve it.
Crosscutting Concept	
Structure and Function	Students make something useful out of some of the substructures of devices they take apart, identifying the function of each structure they use in the new device.