

Engineering Close-Up

TEACHER'S GUIDE

Engineers design technologies that solve problems or meet needs in our everyday lives. The *Engineering Close-Up* series introduces young readers to the ways that engineers solve problems using the engineering design process. Readers learn about the skills engineers use, such as critical thinking and problem solving, to create technologies and how we rely on engineers in our daily lives. The *Engineering Close-Up* Teacher's Guide is a collection of lessons that allow readers to extend their knowledge of engineering in the real world and develop engineering skills as they explore the engineering design process.

Students participating in the inquiry-based lessons in this guide will discover that engineers design technologies to solve problems and meet needs, and make connections to technologies they see and use at home, at school, and in their communities. They will be able to use the engineering design process to identify a problem or need in their classroom and create a solution for it—paying close attention to the planning of a solution and understanding how factors such as materials and other properties make a solution effective. They will understand the purpose of different types of models and be able to create models to represent their ideas.

The lessons in this guide can stand alone, or they can be taught in sequential order, scaffolding in a way that will support students in creating a solution to a classroom problem using the engineering design process. The lessons “A Classroom Waste Problem,” “Make Your Model,” and “Share Your Solution!” are meant to be taught in sequential order, guiding students to follow the steps of the engineering design process over a series of lessons to create their own solutions to reduce waste in their classroom.

The lessons in this guide are tailored for grades 1-2 and aligned to the K-2 Engineering strand of the Next Generation Science Standards and the Understanding Structures and Mechanisms strand of the Ontario Science and Technology curriculum standards. Reproducible worksheets and assessment tools, as referenced in the lesson plans, can be found at the end of the guide. The titles in *Engineering Close-Up* include:

Engineers Build Models
Engineering in Our Daily Lives
Engineers Solve Problems
How Engineers Find Solutions



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PACING CHART AND VOCABULARY

Lesson Plan Title	Pacing	Vocabulary
Observing Problems and Needs in Our World	2 class periods*	engineer observe problem situation solve
Technologies Solve Problems	1 class period	complex computer design human-made needs simple technology tools
Materials and their Properties	1-2 class periods	explore flexible hard heavy light material natural purpose rigid smooth soft solid
Many Materials, Many Properties	1-2 class periods	explore flexible hard heavy light material natural purpose rigid smooth soft solid station
Getting to Know the Engineering Design Process	1 class period	brainstorm communicate engineering design process graphic organizer model plan test
A Classroom Waste Problem	4-6 class periods	compost environment pacific garbage patch plastic pollution solution trash reduce reuse recycle waste
Make Your Model	2-3 class periods	blueprint diagram diorama map model sketch test three-dimensional two-dimensional
Share Your Solution!	2 class periods	communicate present reflect scientific vocabulary share

* 1 class period = 45-60 minutes

ACCOMMODATION STRATEGIES

Accommodations provide equal access to learning and equal opportunity to demonstrate what is learned. Accommodations allow a student access to the subject or course without any changes to the knowledge and skills the student is expected to demonstrate.

Educators are encouraged to adapt the instructional approach, activities, and assessments included in this guide to best meet the diverse interests, needs, and abilities of their students. Possible accommodations may include:

Instructional Strategies

- Break tasks into parts with accompanying time lines
- Provide extra time for processing of oral information.
- Pair oral instructions with visual ones (writing or symbols)
- Pre-teach new vocabulary and regularly review previously taught vocabulary
- Provided model of completed work
- Frequently check with the student to get him/her started
- Provide oral and visual instructions and examples
- Provide a checklist of tasks for the student

Environmental Strategies

- Proximity to teacher
- Strategic seating
- Flexible or mixed-ability grouping
- Provide an alternative setting for learning that is free from visual and auditory distractions.

Assessment Strategies

- Build in extra time to allow student to process questions asked and answers given
- Provide written instructions and rubrics for assignments
- Offer a choice of assessment activities so that the student can choose one suited to their strengths
- Space out or extend assignments to prevent student feeling overwhelmed
- Reduce the number of tasks used to assess skill or concept
- Allow students to use assistive devices or technology

LESSON 1

Observing Problems and Needs in Our World

Curriculum Correlations

Ontario Science and Technology

Grade 1: Understanding Structures and Mechanisms—Materials, Objects, and Everyday Structures

2.2, 2.5

Ontario Language Arts

Overall Expectations 1, 2, 3

Next Generation Science Standards

K-2-ETS1-1.

Common Core State Standards

CCSS.ELA-LITERACY.RI.1.2

Materials

- *Engineers Solve Problems book (Engineering Close-Up)*
- *Observing a Problem or Need Worksheet*
- *Observing a Problem or Need Checklist*
- Chart paper and markers
- Whiteboard and markers

Setting the Stage

Read-aloud of *Engineers Solve Problems* book. Read page four, and stop. Ask students what they think about the multiple-choice question on the page. Hold class discussion about students' thoughts and prompt them to give reasons for their answers.

Class discussion: Explain that the scenario on page 4 is a problem. Write definition of problem on whiteboard or on an anchor chart:

- **A problem is a situation that people want to change or improve.**
- People can change the situation to fix the problem. Or, they can create something new, such as a tool or object.

Divide students into groups and provide them with chart paper and markers. Using the problem on page 4 as an example, ask students to brainstorm other problems they might have experienced at home, at school, or in their community.

- Keep students on track by reminding them that a problem is a situation that we can change, not the way we feel about something.

Have students share their ideas. Write appropriate problems on the board and have students choose three that they feel relate to everyone in the class. Ensure the choices are appropriate.

Objectives

Students will:

- Define a problem as a situation that people want to change or create.
- Define a need as something we must have or do.
- Based on the definition, observe and identify problems in their homes, schools, and communities.
- Identify engineers as people who use science, math, and creative thinking to solve problems.

Activity

Read the remainder of *Engineers Solve Problems* book.

Class discussion: Who solves problems?

- Everyone can solve problems, but engineers are people whose job it is to solve problems. They use science, math, and creative thinking to solve problems.

Discuss: Engineers also use science and math to meet people's needs.

• Needs are things that we must have or do.

- We need a way to write in our notebooks at school.
We need something to sit on when we work at our desks.

Tell students that engineers learn about problems and needs by observing them.

• To observe is to see or notice something.

- Problem-solvers, such as engineers, write down everything they know about a problem before they start to solve it. Then, they write down the things that they still need to know about the problem.

Hand out *Observing a Problem or Need Worksheet* and tell students that they need to choose one of the three problems chosen as a class. They need to draw a picture of the problem, then write down two things they can observe about the problem and one thing they still need to find out.

Model an example of the worksheet using the problem on page 4 of *Engineers Solve Problems*. Give students 15-20 minutes to complete the worksheet.

Extensions

- Students can share their worksheets with a partner and offer them feedback on the information they identified. Students can add ideas to the information that we still need to know about the problem.

Wrap-Up

Review the worksheets together. Invite students to share their drawing, observations, and ideas with a partner or with the class. Ask students to hand in the worksheets for assessment.

Assessment

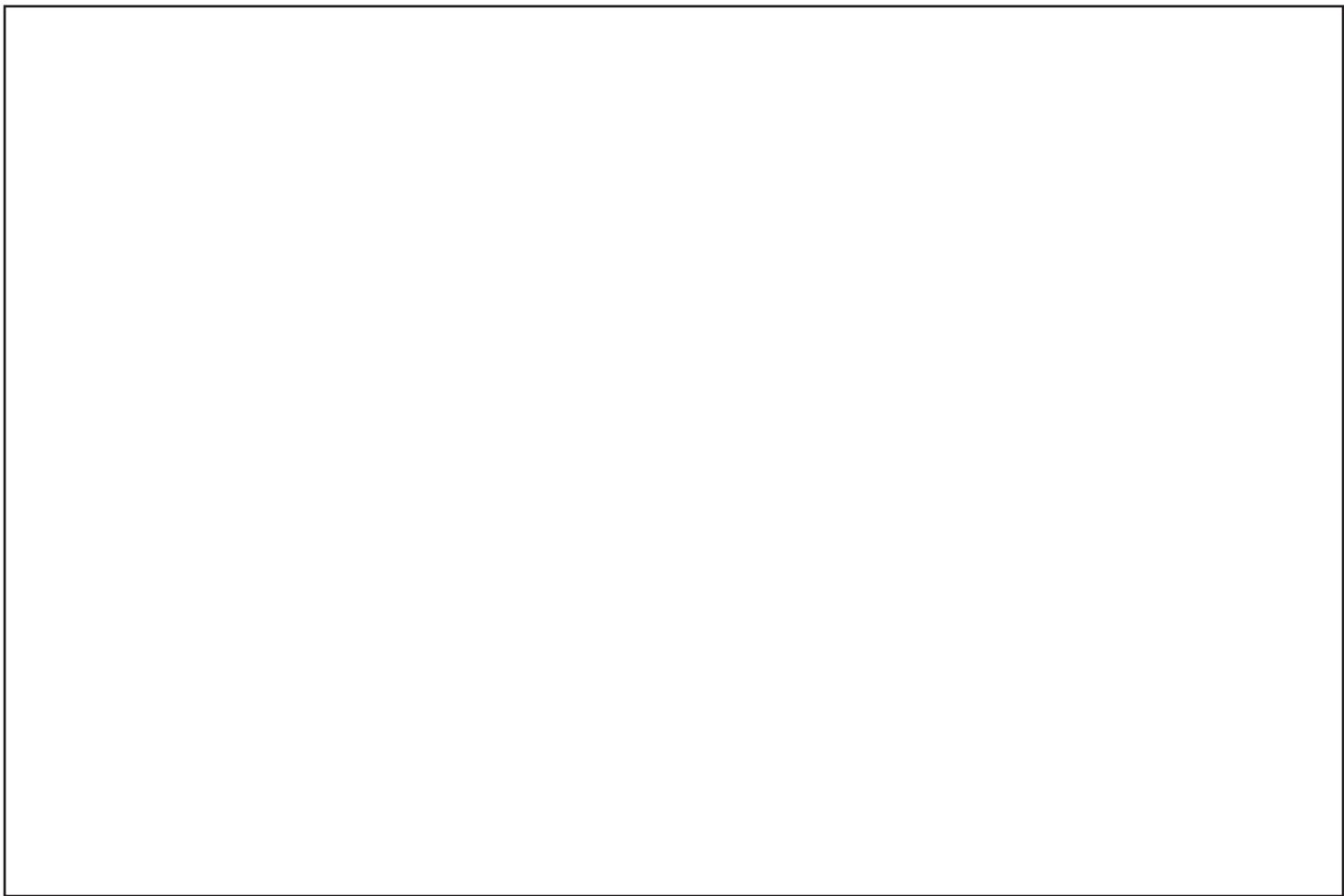
Use anecdotal notes to assess student comprehension based on their participation in class discussion. Assess handout for understanding using the *Observing a Problem or Need Checklist*.

Name: _____ Date: _____

Observing A Problem or Need Worksheet

When you gather information about a problem or a need, you are acting just like an engineer! A problem is a situation that people want change or improve. Use the box below to draw a picture of a problem or need in your community.

One problem in my community is: _____



Write down two details about the problem or need. What do you know about it? Who is affected?

1. _____

2. _____

Write one detail that you still need to find out.

1. _____

Name: _____ Date: _____

Observing A Problem or Need Checklist

Criteria	Level 1	Level 2	Level 3	Level 4
	<ul style="list-style-type: none">• Displays a limited understanding of the problem• Observations are incomplete and/or lack detail	<ul style="list-style-type: none">• Displays an adequate understanding of the problem• Observations are relevant but lack detail	<ul style="list-style-type: none">• Displays a thorough understanding of the problem• Observations are relevant to the problem and provide some insight	<ul style="list-style-type: none">• Displays a sophisticated understanding of the problem• Observations demonstrate keen insight and focus
Picture depicts an appropriate problem clearly.				
Student clearly writes two observations about the problem.				
Student clearly identifies one detail of information that they still need to gather about the problem.				

LESSON 2

Technologies Solve Problems

Curriculum Correlations

Ontario Science and Technology

Grade 1: Understanding Structures and Mechanisms—
Materials, Objects, and Everyday Structures

1.2, 2.2, 2.5, 3.1, 3.3, 3.4, 3.5, 3.6

Ontario Language Arts

Overall Expectations 1, 2, 3

Next Generation Science Standards

K-2-ETS1-1.

Common Core State Standards

CCSS.ELA-LITERACY.RI.1.2

Materials

- *Engineering in our Everyday Lives* book (*Engineering Close-Up*)
- *Technologies in My World Worksheet*
- *Technologies Solve Problems Exit Card*
- *Technologies Solve Problems Checklist*
- Whiteboard and markers
- Pencils

Setting the Stage

Review the concept that engineers use science, math, and creative thinking to solve problems. Write definition of problem on the whiteboard.

- **A problem is a situation that people want to change or improve.**

Read-aloud *Engineering in our Everyday Lives* with class. Engage students in comprehension activities while reading.

- Stop after each spread, or two pages, and ask students to restate the main ideas in the text.
- Students can use the think, pair, share strategy to restate the main ideas.

Review pages 6-7, on which technologies are introduced. Class discussion: What is a technology? Write the definition on an anchor chart:

- **Technologies are the tools created by engineers to solve a problem or meet a need.**

Together with students, add to the anchor chart the characteristics of a technology. Review key vocabulary such as **design**, **simple**, **complex**, and **tools**.

- Technologies are the things designed by engineers to solve a problem or meet a need.
- Technologies can be simple, or made of few parts.
- Technologies can be complex, or made of many parts.
- Tools are technologies. These are objects that make work easier.

Review the examples of technologies in the book and connect them to the problem they solve or the need they meet. Examples from the book might include:

- A computer is a complex technology that meets a person's need to find information quickly.
- A pencil meets a person's need to write down information.
- A vacuum is a tool solves the problem of a dirty carpet.
- A traffic light solves the problem of road accidents.
- Bicycles meet our need to get around.

Follow-up by showing students an example of a technology in the classroom that solves a problem or meets a need.

Objectives

Students will:

- Identify natural and human-made objects that solve problems.
- Define technology as a human-made object designed by an engineer to solve a problem or meet a need.
- Identify and explain everyday technologies and their characteristics, such as their materials.

Activity

Tell students that we are acting as engineers who are learning about the technologies at our school. Hand out the *Technologies in My World Worksheet* and tell students that they are required to write down five technologies that solve different problems in the school community.

Students will identify technologies for different problem categories. Teacher can use prompts during the tour to help guide their understanding.

- What technologies do you see that keep us safe?
- What technologies do you see that help us work together?
- What technologies do you see that help us communicate?
- What technologies do you see that help us learn?
- What technologies do you see that help us follow rules?

Invite students to share ideas and prompt them to write down the technologies they see on the worksheet.

Extensions

- Students can bring in a technology from home or cut out a picture of a technology from a newspaper or magazine to present to the class. They can explain what the technology is and what needs it meets or problems it solves.
- To extend the lesson for the whole class and provide gifted students with an opportunity to showcase their understanding, teacher could prompt students to identify areas where a technology, such as a tool or machine, might be needed in their school community. For example, students could invent a way to more clearly show school visitors the correct direction to the welcome office.

Wrap-Up

Back in the classroom, have students share their worksheets with a partner, then share their responses with the class. Prompt students to come up to the whiteboard to write down one of the technologies they found, until the board is full of responses. Have a class discussion about the needs these technologies meet or problems they solve.

Hand students Technologies Solve Problems Exit Card and tell them that they need to use the anchor chart to define technology in their own words. Then, they need to choose one of the technologies found in the school community and describe the problem it solves or the need it meets. Can model one example in front of the class first.

Assessment

Use the *Technologies Solve Problems Checklist* to assess student participation on the school tour and student comprehension based on the exit card.

Name: _____ Date: _____

Technologies in My World Worksheet

Take a trip around our school community and write down 5 the technologies you see.

Identify five technologies in our school community.

1. Write a technology that helps keep us safe.

2. Write a technology that helps us work together.

3. Write a technology that helps us communicate.

4. Write a technology that helps us learn.

5. Write a technology that helps us follow rules.

Name: _____ Date: _____

Technologies in My World Exit Card

What is a technology? Use your own words. Check the class anchor chart for help.

Name one example of a technology in our school community. Describe the need it meets or the problem it solves.

Name: _____ Date: _____

Technologies in My World Checklist

Criteria	Level 1	Level 2	Level 3	Level 4
	Displays a limited understanding of what a technology is and is not able to correctly identify examples around school community.	Displays an adequate understanding of what a technology is and needs some assistance identifying examples around school community.	Displays a thorough understanding of what a technology is and identifies accurate examples around school community.	Displays a sophisticated understanding of what a technology is and shows insight when identifying examples around the school community.
Student participates in tour around school and writes down 5 technologies in the school community..				
On Exit Card, student wrote the definition of a technology in his or her own words. Student's definition makes sense and fits with the characteristics of a technology as described in the book.				
On Exit Card, student names one technology in the school community and describes, using target vocabulary such as "problem" and "need," the need it meets or problem it solves.				

LESSON 3

Materials and their Properties

Curriculum Correlations

Ontario Science and Technology Standards

Grade 1—Understanding Structures and Mechanisms:
Materials, Objects, and Everyday Structures

2.1, 2.2, 2.3, 2.5, 3.1, 3.3, 3.5, 3.7

Next Generation Science Standards

K-2-ETS1-1.

Materials

- Everyday technology, such as a helmet
- Whiteboards with dry erase markers and erasers—1 per student
- Chart paper and markers
- Video projection tool, such as a SmartBoard
- *Properties at Home Worksheet*
- *Materials and their Properties Assessment Sheet*

Objectives

Students will:

- Use scientific vocabulary to identify that materials have different properties.
- Explain that the materials chosen to make up certain objects are related to that object's purpose.
- Connect materials in technologies to the problems they solve or needs they meet.

Setting the Stage

Gather class in a circle, and hold up a helmet. Have a short discussion about it using the following prompts:

- What is this object?
- Do you use a helmet? When?
- What problem does a helmet solve?
 - A helmet helps keep our heads safe when we are doing activities such as biking and skiing.

Tell students: a helmet is an object. Write definitions on the board or on anchor chart:

- **An object is a thing that is made of one or more materials.**
- **Materials are the substances from which something is made.**

Pass the helmet around the circle. Tell students to use their senses to see what they can observe about the helmet. Prompt them with some questions as the helmet goes around the circle:

- What does the helmet look like?
- What does the helmet feel like?
- What words would you use to describe the helmet?

Tell students: A helmet is made of different materials.

- The part on the top is made of smooth, hard plastic.
- On the inside, there is hard foam.
- The part that snaps around our chins is strong and soft fabric.

Explain that smooth, hard, strong, and soft are all properties of materials. Write definition of properties on the whiteboard or on an anchor chart:

- **Properties are the observable characteristics of objects and their materials.**

Ask students:

- Why do you think the helmet is made from materials with these properties?

Show students the Scholastic video at the link below. This video introduces properties of objects, and gives examples that show how certain materials are chosen for certain purposes.

<https://bit.ly/2ItWvgm>

Discuss: The properties of materials chosen in objects suit their purpose. Give some examples to help consolidate students' understanding:

- We sleep on a pillow that is stuffed with soft material.
- We brush our hair with a comb that is made of stiff material, to get rid of the knots.

Ask students to share any examples that they can think of on their own.

Setting the Stage

There are many different types of properties! Explain to students that we will be exploring the properties of the materials in different everyday objects.

Hand out whiteboards, markers, and erasers—1 per student.

On an anchor chart, write the title “Properties of Materials”. For each property, follow these steps:

1. Write the property name and definition on the anchor chart.
2. Ask students to draw a picture of an object or material that has that property on their whiteboard.
3. Invite students to hold up their whiteboards to share their drawings with the teacher and with each other.
4. Assess students’ understanding of concepts in real-time based on the drawings they hold up.

Introduce, define, and solicit drawings for the following properties (teacher can alter property list based on class initiatives):

- Natural: The material comes from the natural environment.
- Human-made: Humans made the material. It is not natural.
- Heavy: The material takes effort or is difficult to lift or move.
- Light: The material is easily lifted or moved.
- Flexible: The material is easy to bend.
- Rigid: The material is hard to bend.
- Hard: The material is solid and difficult to break.
- Soft: The material is not solid. Its shape can change when we touch it.

Extensions

- Take a tour around the schoolyard. Identify different natural and human-made objects and the materials they are made of. Describe how they meet their purpose.

Wrap-Up

Review the 8 properties introduced in this lesson. Hand out *Properties at Home Worksheet* and tell students that they will need to choose one of the 8 properties and find three objects at home that use a material with that property. Collect the worksheets at the start of the next day.

Assessment

Use *Materials and their Properties Assessment Sheet* to make anecdotal notes on and assess students’ comprehension based on their participation in this lesson and their at-home activity.

Name: _____ Date: _____

Properties at Home Worksheet

Choose one of the 8 properties we discussed in class today. Use the Property Word Bank below to remember their names.

Find three objects at home that have materials with that property.

The property I chose is: _____

Three objects at home that have materials with that property are:

1. _____

2. _____

3. _____

Property Word Bank

Heavy	Flexible
Light	Rigid
Natural	Hard
Human-made	Soft

Name: _____ Date: _____

Materials and their Properties Assessment Sheet

Anecdotal Notes

Did the student participate in the class discussion and whiteboard activity? Did the student use target scientific vocabulary in class discussions? Did the student's drawings show comprehension of the 8 properties introduced in class today?

Criteria	Yes	No
Did the student choose one of the 8 properties discussed in class and write it on the worksheet using correct scientific terminology?		
Did the student identify three objects at home that use materials with a certain property?		

LESSON 4

Many Materials, Many Properties

Curriculum Correlations

Ontario Science and Technology Standards

Grade 1—Understanding Structures and Mechanisms:
Materials, Objects, and Everyday Structures

2.1, 2.2, 2.3, 2.5, 3.1, 3.3, 3.5, 3.7

Next Generation Science Standards

K-2-ETS1-1.

Setting the Stage

Hand out the whiteboards, markers, and erasers—1 per student.

Teacher draws on the large whiteboard or holds up a picture of a material. Instruct students to write one property word that describes that material on their whiteboard.

Prompt students to hold up their whiteboards and assess their comprehension of the concepts in real-time. Review any properties for which there is confusion.

Materials

- Timer
- Whiteboards, dry erase markers, and erasers—
1 per student
- Large whiteboard and markers, or printed pictures of
different materials
- *Many Materials, Many Properties Investigation Chart*
- *Materials and Solutions Worksheet*
- *Many Materials Checklist*
- 4 everyday technologies and two natural objects
 - Small garden shovel
 - Blanket
 - Wood chips (natural)
 - Balloon
 - Bird's nest (natural)
 - Rubber band

Objectives

Students will:

- Use scientific vocabulary to describe the properties of a range of everyday objects.
- Make connections between the materials used in a technology and the problem it solves or the need it meets.

Activity

Prior to lesson set up stations around the room where students can investigate different technologies and the properties of their materials. Each station will have one technology made up of one or many materials. There should be a mix of natural and human-made technologies.

Suggested materials for 6 stations:

- Small garden shovel
- Blanket
- Wood chips
- Balloon
- Bird's nest
- Rubber band

Tell students that they will investigate the properties of different materials at stations around the room. Explain that they will have five minutes at each station to use their senses to explore the object there. At each station, they will fill out their worksheet by choosing two properties from the word bank to describe the materials used in the object there.

Hand out *Many Materials, Many Properties Investigation Chart*—one per student. Divide students into six groups and start each group at one station. Set the timer for five minutes and time students at each station. While students are moving through the stations, teacher can choose to move to different stations with them or stay with one group that might have higher needs.

Extensions

When time is up, have students return to their desks with their worksheets. Review the materials and properties at each station together. Have students share their answers.

- During the station activity, teacher can conference with individual students and ask them to make connections between the object on the table, its materials, and what it is used for.
- Invite gifted students to lead the “review” of one station.

Wrap-Up

Hand out *Materials and Solutions Worksheet* to students. Explain to them that this is a way for them to show that they understand the connection between the materials used in technologies and the problems they solve or needs they meet. Teacher should collect *Many Materials, Many Properties Investigation Chart* and *Materials and Solutions Worksheet*.

Model the first scenario with students so that they understand how to complete the worksheet. Then, have them complete the other two scenarios by themselves. Students should hand in the sheets when they are finished.

Assessment

Use *Many Materials Checklist* to assess students' participation in the class activity, and their comprehension of how materials used in different technologies relate to their purpose on the worksheet.

Name: _____ Date: _____

Many Materials, Many Properties Investigation Chart

Use your senses to explore the materials in the object at each station.

Choose two words from the Property Word Bank below to describe the materials at each station.

Write the words in the chart below. Then, identify whether the object is natural or human-made.

Object	Properties	Natural or Human-made?
Garden Shovel	_____	<input type="checkbox"/> Natural <input type="checkbox"/> Human-made
Blanket	_____	<input type="checkbox"/> Natural <input type="checkbox"/> Human-made
Wood chips	_____	<input type="checkbox"/> Natural <input type="checkbox"/> Human-made
Rubber band	_____	<input type="checkbox"/> Natural <input type="checkbox"/> Human-made
Balloon	_____	<input type="checkbox"/> Natural <input type="checkbox"/> Human-made
Bird's nest	_____	<input type="checkbox"/> Natural <input type="checkbox"/> Human-made

Property Word Bank

Heavy	Rigid
Light	Hard
Flexible	Soft

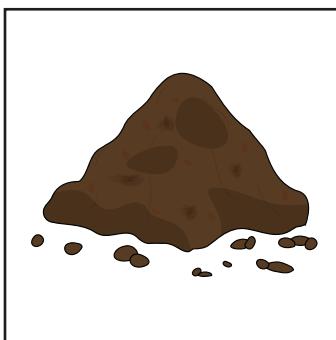
Name: _____ Date: _____

Materials and Solutions Worksheet

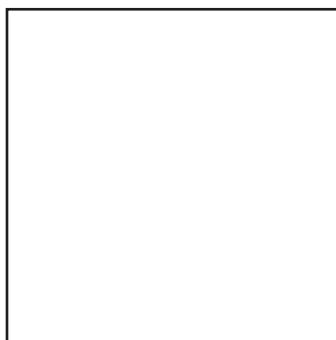
Use the technologies bank and the word bank to fill in the blanks below.

For each section, draw a picture of the missing technology in the empty box. Then, fill in the missing words in the sentence.

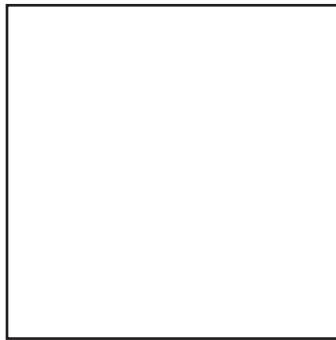
Problem or Need



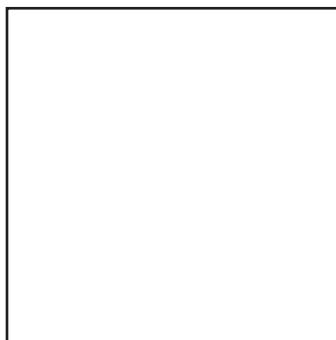
Technology



This technology is made of _____ materials so that it can lift a _____ load.

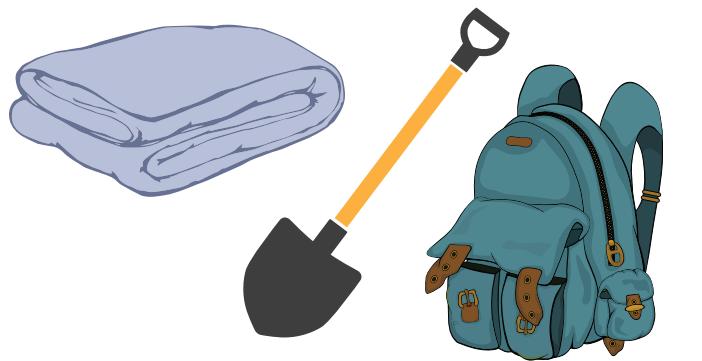


This technology is made of _____ materials so it can keep a person _____.



This technology is made of _____ materials so it is _____ to carry.

Technologies Bank



Word Bank

Heavy	Rigid	Warm
Light	Hard	Easy
Flexible	Soft	

Name: _____ Date: _____

Many Materials Checklist

Criteria	Met	Not Met	Notes
During class activity, student participated at each station and checked the appropriate square on their worksheet.			
Student displayed their understanding of the connection between a problem or need and a technology as a solution by drawing a picture of the correct technology in the empty square.			
Student displayed their understanding of materials and their purposes by filling in the incomplete sentences with the correct words.			

LESSON 5

Getting to Know the Engineering Design Process

Curriculum Correlations

Ontario Science and Technology

Grade 1: Understanding Structures and Mechanisms—
Materials, Objects, and Everyday Structures

2.4, 2.6

Ontario Language Arts

Overall Expectations 1, 2, 3

Next Generation Science Standards

K-2-ETS1-1.

K-2-ETS1-2.

Common Core State Standards

CCSS.ELA-LITERACY.RI.1.2

Materials

- Pages 12-13 of *Engineers Solve Problems* (*Engineering Close-Up*)
- One everyday classroom technology
- *Engineering Design Process Graphic Organizer*
- *Engineering Design Process Assessment Checklist*
- Chart paper and markers
- Large chart paper with large version of *Engineering Design Process Graphic Organizer*
- Timer

Setting the Stage

Hold up or draw students' attention to an everyday classroom technology, such as a backpack, a desk, a paper organizer, a shelf, or a garbage can. Ask students:

- What need does this meet or problem does it solve?
- What materials is this technology made of that make it work or serve its purpose?
- Is there a way that we could change this technology to make it better?
 - ▶ Write students' ideas down on the whiteboard so that they can see what brainstorming looks like.
- Is there a new technology we could create that would meet that need in a new way?
 - ▶ Write down ideas on whiteboard.

Engage students in discussion: You are all acting like engineers!

- Engineers are never satisfied! They always look for new ways to solve problems and meet needs, and ways to improve existing technologies to make them better suited for a need or a problem.

Objectives

Students will:

- Understand and describe the steps in the engineering design process.
- Describe how an engineer uses the engineering design process to design new technologies and improve existing technologies that solve problems and meet needs.
- Use a graphic organizer to display their knowledge.

Activity

Review pages 12 and 13 in the Engineers Solve Problems book. Review with students that whenever they design new technologies or change existing technologies, engineers use the engineering design process!

Review the steps of the engineering design process with students.

- **Find a Problem:** Ask questions about the problem or need to learn about it.
- **Brainstorm:** Work with a group to come up with different ways to solve the problem or meet the need in an improved way.
 - **A brainstorm is a group discussion to produce ideas.**
- **Plan and Make a Model:** Choose the best solution after brainstorming. Create a plan to make a model of the solution and gather the materials you need.
 - **A model is a representation of a real object.**
 - A model can be a sketch or drawing, or a physical creation.
- **Test and Improve:** Test or get feedback on your model. Record, or write down, the results. Use the rest results to improve your design, and retest. Repeat process until you are happy with your solution.
- **Communicate:** Share your solution with others.

Co-create an anchor chart of each of the steps to display in the classroom.

Establish class definitions for each step in the engineering design process and write those on the anchor chart.

Give a different example of an everyday classroom technology and tell students that as a class, we will use the engineering design process to change the technology to make it work better or do something that it could not do before. Or, we can choose to create an idea for a new technology that solves the same problem or meets the same need.

Prior to lesson, recreate graphic organizer from *Engineering Design Process Graphic Organizer* on large chart paper.

- Teacher fills in large graphic organizer.

Each student gets their own copy of the *Engineering Design Process Graphic Organizer*. Students fill in their graphic organizer along with the teacher.

Model the engineering design process with students.

For example: Teacher chooses a backpack as the classroom technology.

- **Find a Problem:** *How could we improve this backpack so that it better meets our need to safely carry school supplies?* Write down question on chart paper graphic organizer. Prompt students to write down the question on their own graphic organizer.
- **Brainstorm:** Have students share ideas. Write down the ideas on the graphic organizer. Prompt students to write down the ideas on their graphic organizer.
 - For example, use a lighter material to make it easier to carry, attach an umbrella to keep its contents dry in rain, add soft or plushy material to the straps to make it more comfortable, etc.
- **Plan and Make a Model:** Have students choose the best idea as a class. Write down that idea on the graphic organizer and prompt students to do the same. Then draw a picture of the idea. Teacher can draw the picture using student input. Prompt students to draw a picture on their graphic organizer.
- **Test and Improve:** *How can we improve our design?* Tell students that engineers often build models with physical materials or on the computer, then test them to see if they work. This time, we will keep our model on paper. Draw a new design with improvements. Prompt students to draw the improved design, too.
- **Communicate:** On the graphic organizer, use one class-created sentence to communicate how the new or improved technology better meets the need or solves the problem. Prompt students to write the sentence on their worksheet.
 - To share solution, post the large graphic organizer with the class solution in the hallway to share with other students in the school, or take a photo and post it on the class website to share it with parents.

Extensions

- In a subsequent class, students could build a physical model of the new or improved classroom technology and go through the testing steps to see how well it works.
- Can share technology with other members of school community—such as reading buddies from an older class, members of staff, parents—and explain to them how it meets the need or solves the problem.

Wrap-Up

Review the graphic organizer as a class to consolidate understanding of the steps in the engineering design process. Have students hand in their *Engineering Design Process Graphic Organizer*.

Assessment

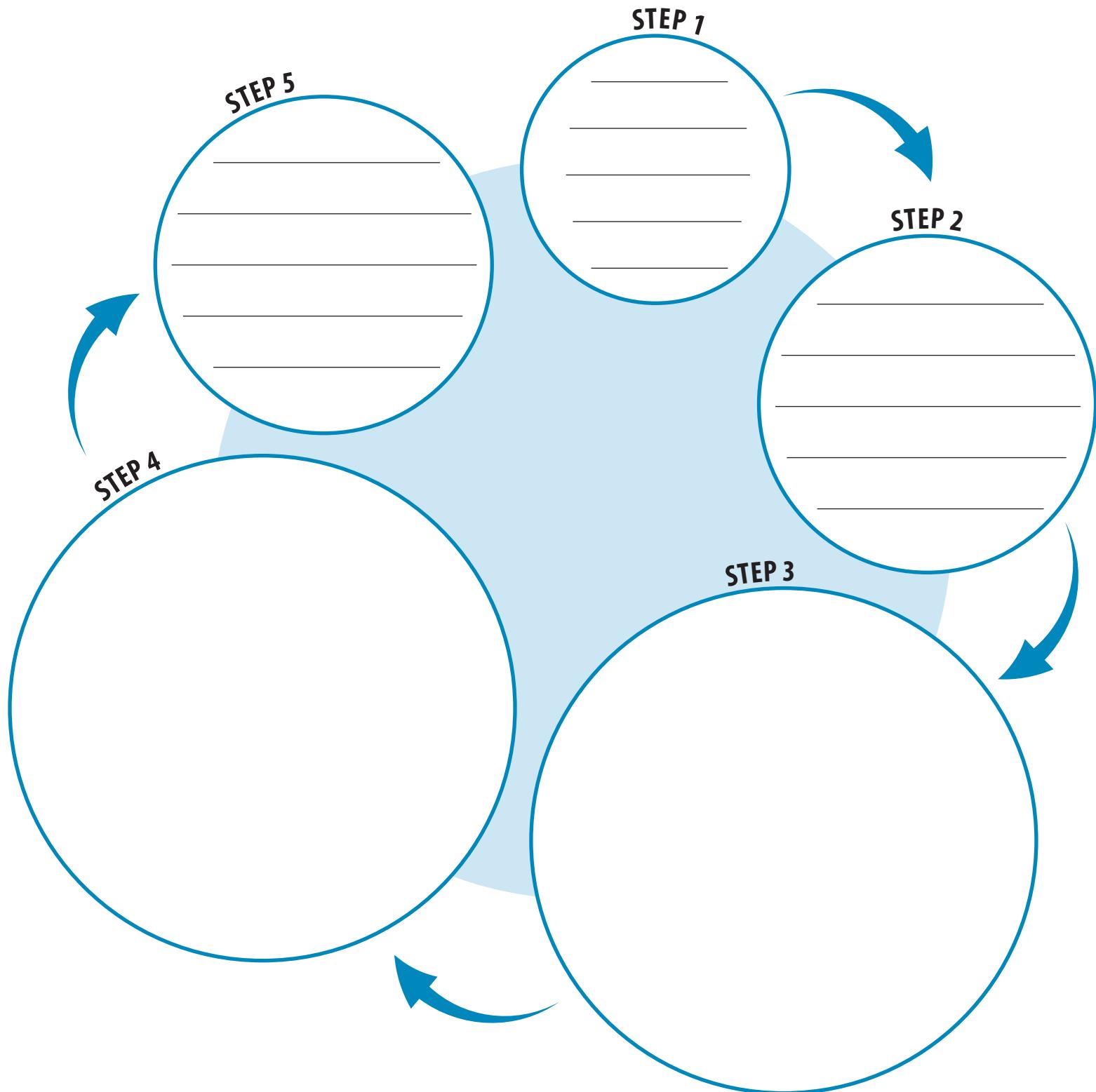
Assess students' comprehension of the engineering design process and its application using the assessment checklist at the bottom of the *Engineering Design Process Graphic Organizer*.

Name: _____ Date: _____

Engineering Design Process Graphic Organizer

You can act like an engineer by using the engineering design process to improve the classroom technology or create a new technology that will meet the same need or solve the same problem.

Use the graphic organizer below to fill in our class's ideas for each step



Name: _____ Date: _____

Engineering Design Process Assessment Checklist

Criteria	Met	Somewhat Met	Did Not Meet
On graphic organizer, student asks questions, makes observations, and gathers information about the classroom technology.			
Student uses problem-solving skills to design or improve a technology for a specific purpose.			
Student uses a graphic organizer to communicate their ideas clearly and effectively.			
Student develops a simple sketch or drawing to illustrate the class solution, and draws a second sketch to illustrate the improvements to the class solution.			

Notes:

LESSON 6

A Classroom Waste Problem

Curriculum Correlations

Ontario Science and Technology Standards

Grade 1: Understanding Structures and Mechanisms—Materials, Objects, and Everyday Structures

1.1, 2.5

Ontario Language Arts

Overall Expectations 1, 2, 3

Next Generation Science Standards

K-2-ETS1-1.

Common Core State Standards

CCSS.ELA-LITERACY.RI.1.2

Materials

- Engineers Find Solutions book (*Engineering Close-Up*)
- Planning a Classroom Waste Solution Worksheet
- Create a Classroom Waste Solution Assessment Page #1
- Chart paper and markers
- A range of craft materials that students can gather to use for their model
- Large tarp paper
- Garbage from previous school day, to complete waste audit
- Scale
- 4-6 garbage bags
- 1 bucket for compost (food waste)
- Rubber gloves—1 per person

Objectives

Students will:

- Participate in a classroom waste audit and identify too much waste as a problem that needs to be solved.
- Use scientific vocabulary and their understanding of the engineering design

process to brainstorm solutions to create a technology or process that will reduce classroom waste.

- Create a plan to make a model of their best solution.

Setting the Stage

Have a class read-aloud of *How Engineers Find Solutions*. Review definition with students:

- **A solution is an answer to a problem.**
 - A solution can be an object or a technology, or it can be a process, which is a new way of doing things.
- Review the engineering design process. This is found on pages 12-13 of *How Engineers Find Solutions*. Have a visual of the engineering design process on the board or on an anchor chart in the classroom.
- Discuss: Engineers can solve many different kinds of big and small problems. One problem we can help solve is the problem of waste causing pollution in the environment! Have a discussion in which students can share their ideas and teacher can assess prior knowledge. Ask students:
- What is pollution? **Pollution happens when harmful things enter into the environment.**
 - ▶ Show students an image of plastic waste in an ocean or an animal covered in oil

- What is waste? **Waste is a material that is not wanted.**
It is the garbage we throw away.
 - ▶ What is some of the waste you create?
- Where have you seen waste create pollution in our community?
 - ▶ Show students some images of litter in a park or in the schoolyard.

Show students the following National Geographic video:

- Trash of a Human Lifetime <https://bit.ly/2qVDT1p>
 - ▶ This short video explains the huge amount of trash each person creates in their lifetime using relatable terms and images, such as number of trucks filled with waste and numbers of bottles thrown away. The video will introduce students to the problem of increased waste production and how it harms the environment.
 - ▶ Link to National Geographic source: <https://on.natgeo.com/2ltWLvG>

Setting the Stage

Have class discussion: How does waste hurt the environment?

- Waste pollutes the environment. It can damage habitats and hurt animals.
Waste can make it hard for plants to grow and the oceans to be safe for wildlife.

Ask students: What are some ways that people help stop waste entering the environment?

- **Reduce**

- ▶ This means lowering the amount of waste that we throw away.
We can lower our waste by shopping for things that do not come in packaging or by trying to avoid using things that we will want to throw away later.

- **Reuse**

- ▶ This means using the same things over and over again. We can save trees and forests by reusing paper. We can reuse containers to avoid using plastic. We can reuse clothing, toys, and books by giving them away or shopping at thrift stores.

- **Recycle**

- ▶ This means turning old things into new ones. We can recycle paper, cardboard, newspaper, glass, plastic, and aluminum so it can be sent to a factory and made into new recyclable items.

Tell students: Whenever we save materials from going to waste, it is good for the environment. We can make a difference against pollution by using the engineering design process to create a solution that helps reduce the waste in our classroom!

Activity #1

Classroom Waste Audit

Explain to students that today, we will take a close look at the waste we create as a class. By observing the waste that we created in a day, we can start to think of ways that we can solve the problem of too much waste.

Steps for classroom waste audit:

1. Teacher and all students put on rubber gloves.
2. Collect all of the waste created by the class the day before. Separate trash and recyclables into two separate bags.
3. On chart paper, create empty two bar graphs.
 - a. X-axis has the following labels: Trash, Recyclables, Compost, Reuse
 - b. Y-axis has weight in pounds or kilograms: 0-10 pounds or 0-5 kilograms (with half measurements) should suffice

4. Post graphs on the board or on a wall so students can see them.
5. With students help, use the scale to weigh the bag of trash and the bag of recyclables. Record the weights on one bar graph (compost and reuse will be empty).
6. Dump both bags on the tarp and spread it all out.
7. Gather students around the tarp and explain that we can create ways to reduce the weight of trash we created.
 - a. Compost is food waste. We can put it into the soil and it will break down.
 - b. Reuse is things in the trash that we could use again.
8. Have students sort the trash on the tarp into 4 piles and place them in bags:
Trash, Recyclables, Compost, Reuse
9. With students help, use the scale to weigh each of the 4 bags. Record the weights on the remaining bar graph (compost and reuse will be empty).
10. Compare two graphs and talk about how they changed before and after we took steps to reduce trash.

Source: <https://bit.ly/2yBq5QE>

Write the problem on the board. **Our classroom creates too much waste, which pollutes the environment.**

Tell students that, in pairs, they will be completing all of the steps of the engineering design process to create a solution to the problem—their solution needs to reduce the amount of waste that our classroom creates.

Create success criteria for this lesson together with students.

Success criteria could include:

- Chose one idea after the classroom brainstorming process
- Wrote a plan about how they will make a model of their idea.
- Drew a sketch showing how their model will look.
- Gathered the materials they will need for their model, or made a plan to gather the materials they will need before the next lesson.

Activity #2

Brainstorm and Make a Plan

Now that we have chosen the problem, the first step for us is to brainstorm!

Arrange students in a circle in the center of the classroom and place a large piece of chart paper in the center of the circle. Each student receives a marker. Write the problem in the middle of the chart paper and instruct students to use words and pictures to write down all of the waste-reduction solutions they can think of.

- Teacher should evaluate the ideas being scribed by the students to ensure that they are appropriate and realistic. Teacher should guide students in the correct direction by suggesting appropriate ideas. Some solutions that teachers could look for or suggest are:

- ▶ Different forms of reusable containers
- ▶ Create a “no waste” shopping list
- ▶ Increase recycling and recycle correctly
 - ▶ Create signs for recycling boxes with pictures, so that students know which items can be recycled.
 - ▶ Create recycling organizer
- ▶ Reusable items bin
 - ▶ Scrap paper bin that can be reused instead of thrown out
- ▶ Create “waste board” where class can track the amount of waste they create each day
- ▶ Create a design for a reusable water bottle that attaches to the desk
- ▶ Plan a “No More Waste” school campaign to get other kids interested in the cause

Place students in groups of 3, and hand them copies of *Planning a Classroom Waste Solution Worksheet*—one per student.

Explain to students that in their groups, they will choose one of the solutions from those on the chart paper and create the solution following the rest of the engineering design process steps. On their worksheets, they will make a plan to create a model of their solution. Remind students that a plan includes the following things:

- A sketch showing how the model will look
- A list of materials they will need
- The steps they will follow to make the model

Remind students that a model can take different forms. Write the options students have for their models on the whiteboard:

- Models can be two-dimensional, or drawn on paper.
 - ▶ Models can be diagrams drawn on paper. Diagrams have labels.
 - ▶ Models can be blueprints or maps drawn on paper.
 - ▶ Models can be a list of steps or a storyboard that shows how a process, or new way of doing something, will work.
- Models can be three-dimensional, or physical objects.
 - ▶ A model can be a diorama, or a 3-D creation of how something will look.
 - ▶ A model can be an object with different parts that fit together.

Extensions

- During computer time, have students extend their knowledge of waste sorting and recycling by completing the *What Goes Where?* Game.
 - ▶ Sort waste into its appropriate disposal option: <https://edmonton.recycle.game/>
- Can conduct exploration of what happens to a specific classroom material when it goes in the garbage. Where does it go? How long does it sit in a landfill? How might it, specifically, damage the environment?

Wrap-Up

Give students extra time to complete their planning worksheets and self-assessments. Have the students take five minutes to gather all of the materials they will need. Prompt students to tell the teacher if there are materials they need that are not already available.

Teacher will conference with each group individually to ensure they’re on track. Ask each group if they need any additional materials.

Ask students to hand in worksheets for assessment. Hand the worksheets back to them at the beginning of the next class. Remind students that next class, they will create models of their ideas, so make sure they have planned well.

Assessment

Use *Create a Classroom Waste Solution Assessment Page #1* to assess students’ worksheets, their participation in the class brainstorming activity, and their responses during conferencing time.

Name: _____ Date: _____

Planning a Classroom Waste Solution Worksheet

Our classroom waste solution:

Planning our model

How will you show your idea? Write down the steps your group will take to build a model of your solution. Will your model be an object or a process?

Materials we will need

Write down all of the materials you will need to build your model.

Draw a picture of how your model will look.

Self Assessment: Check Yes or No	Yes	No
Write down ideas for solutions during the class brainstorm?		
Help my group choose one solution and make a plan to create a model of the solution.		
Draw a picture of how my model will look?		
Gather the materials I need to make the model, or tell my teacher the materials that I still need to create my model?		

Name: _____

Date: _____

Create a Classroom Waste Solution Assessment Page #1

Criteria	Level 1	Level 2	Level 3	Level 4
	Limited understanding of problem and planning process is displayed.	Adequate understanding of problem and planning process is displayed.	Thorough understanding of problem and planning process displayed.	Exceptional understanding of problem and planning process displayed.
Student participated in the brainstorming activity by writing down at least 1 idea on the chart paper.				
During group conference, student could explain the group's plan for the model and the materials they needed.				
Student completed the worksheet and the self-assessment chart, showing understanding of content and self-reflection on their performance.				

LESSON 7

Make Your Model

Curriculum Correlations

Ontario Science and Technology Standards

Grade 1: Understanding Structures and Mechanisms—Materials, Objects, and Everyday Structures

2.1, 2.4

Ontario Language Arts Standards

Overall Expectations 1, 2, 3

Next Generation Science Standards

K-2-ETS1-2.

K-2-ETS1-3.

Common Core State Standards

CCSS.ELA-LITERACY.RI.1.2

Materials

- *Engineers Build Models* book (*Engineering Close-Up*)
- *Testing My Model Worksheet*
- *Testing Models Self Assessment*
- *Create a Classroom Waste Solution Assessment Page #2*
- Chart paper and markers
- Whiteboard and markers
- A range of materials that students can gather to use for their model

Setting the Stage

Class read-aloud of *Engineers Build Models*.

Review concepts in the book by asking students:

- What is a model?
 - ▶ **A model is a representation of a real object.**
- Why do engineers use models when they design solutions?
 - ▶ Engineers design models to communicate, or show others, their ideas.
 - ▶ A model can show how different parts of an object work together.
 - ▶ A model can show how something looks or how a process will be done.

Remind students that there are many ways that we can make models. Write the different ways models are made on the whiteboard.

- Models can be two-dimensional, or drawn on paper.
 - ▶ Models can be diagrams drawn on paper. Diagrams have labels.
 - ▶ Models can be blueprints or maps drawn on paper.
 - ▶ Models can be a list of steps or a storyboard that shows how a process, or new way of doing something, will work.
- Models can be three-dimensional, or physical objects.
 - ▶ A model can be a diorama, or a 3-D creation of how something will look.
 - ▶ A model can be an object with different parts that fit together.

Hand students the Planning a Classroom Waste Solution Worksheet that they completed in the previous lesson. Tell them that they will now complete the next step of the engineering design process—making their models, testing them, and improving them. In the test stage, they will give feedback on two other groups' models. Then, they will review the feedback their model received and improve it.

Together with the students, create success criteria for the model.

- **Did I...**
 - ▶ Build or draw a model that communicates my solution to others?
 - ▶ Clearly show how the process will work or how the parts will fit together?
 - ▶ Show others how my model solves the classroom waste problem?

Objectives

Students will:

- Create a model of their solution to a classroom waste problem.
- Use the steps in the engineering design process to test their model, give feedback on other students' models, and improve their own model.

Activity

Give students a class period to create their models. Conference with groups as they create their models to ensure that they are on the correct path.

When the models are complete, hand out *Testing My Model Worksheet*—one per group. Prompt students to fill out the group names, date, and name of their solution. They should stop at that point.

Ask students: Why do engineers test models? Prompt students to understand the following points from the *Engineers Build Models* book:

- People can review the model and give feedback, or suggestions, to the engineer to help make the design better.
- Testing models helps engineers know if their ideas will work and are safe.
- When engineers test models, they sometimes recreate the environment in which the solution will be used.

How will we test our classmates' models in our version of the engineering design process? Give students a list of steps to follow at each model they "test". Write the steps on the whiteboard.

1. Describe the solution.
2. Did the solution solve our classroom waste problem? How do you know?
3. List the materials used for the model. Write a word to describe the property of each material.
4. On the Testing My Model worksheet at the table, write your group names.
5. On the worksheet, write at least one tip that your classmates can use to improve their model.

With students, create feedback for the testing part of the lesson.

- **Did I...**

- ▶ Observe the model's properties and make sure it solves the problem or meets the need?
- ▶ Follow the steps on the whiteboard?
- ▶ Write down at least one tip on how the model could be improved?

Have students leave their models on a desk with the *Testing My Model Worksheet*. Prompt them to rotate clockwise to two other models and give each model feedback on that group's *Testing My Model Worksheet*. Give students 10 minutes at each model to follow the steps on the whiteboard.

After two tests, students go back to their models. Explain to students that now, they will use the feedback they received to improve their models. With students, create criteria for improving the model.

- **Did I...**

- ▶ Look at all of the feedback I received from my classmates?
- ▶ Write down at least one way that I can improve my model?
- ▶ Talk with my group about how I will implement the improvement?
- ▶ Create a new sketch or a new plan for the improved model?

Give students one final class period or half of a class period, depending on need, to improve their model based on the suggestions on the worksheet. They will fill in the remainder of the worksheet.

Extensions

- If class times allows, have students do a second iteration of the testing process.
- Have class discussion about the process. Ask students to reflect on the feedback they gave to other students, and how they feel their feedback could be improved if they were to take part in an engineering design process activity in the past.

Wrap-Up

Have students complete the *Testing Models Self Assessment*, then hand in for review. Guide students to store their improved models in a safe place.

Assessment

Use *Create a Classroom Waste Solution Assessment Page #2* to assess students' understanding. While students are creating their models and testing the models of other students, teacher should conference with students to assess their understanding.

Group Names: _____ **Date:** _____

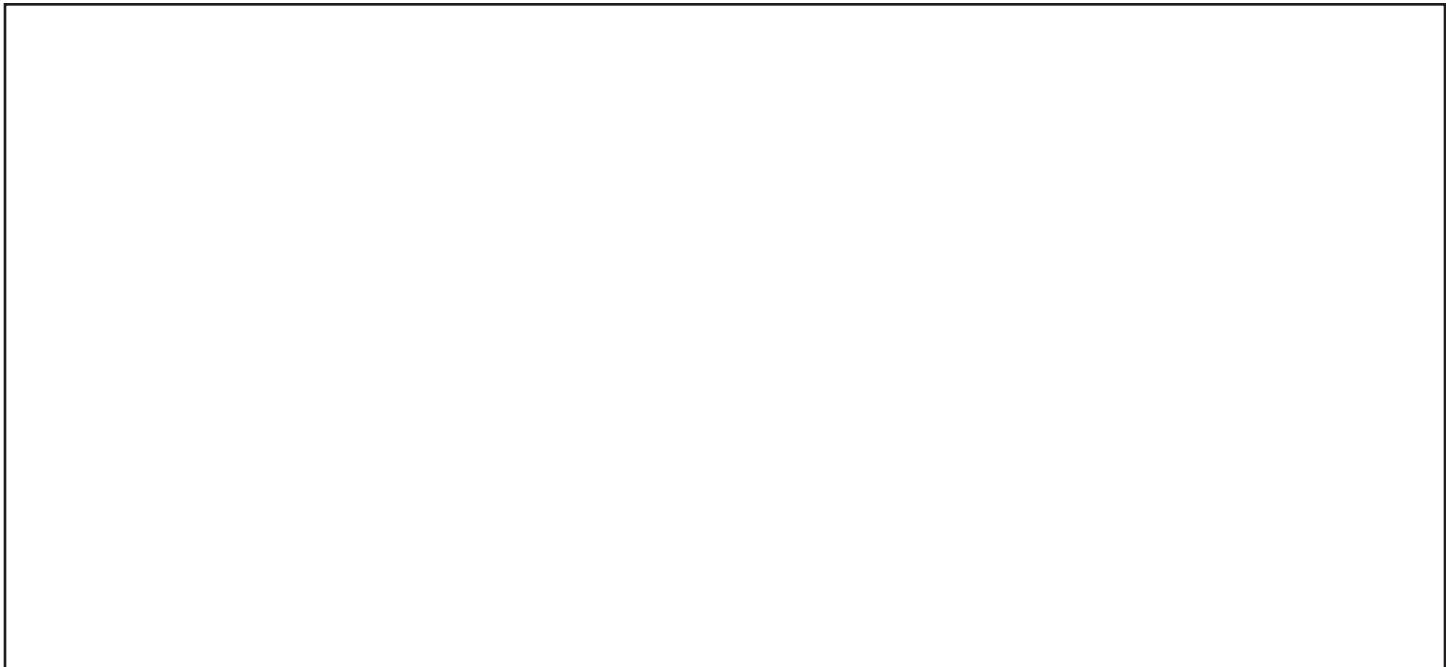
Testing My Model Worksheet

Solution: _____

Names of Test Group	Feedback

Write down at least one way you will improve your idea based on the feedback you received from the other group.

Draw a picture of how your model will look.



Name: _____ Date: _____

Testing Models Self-Assessment

Did I...	Yes	No
Help my group make a model of our classroom waste solution?		
Write feedback for two other models that were created by my classmates?		
Help my group identify at least one way we can improve our model?		
Help my group create a new model including the improvement?		

Name: _____ Date: _____

Create a Classroom Waste Solution Assessment Page #2

Criteria	Level 1	Level 2	Level 3	Level 4
	Limited understanding displayed.	Adequate understanding displayed.	Thorough understanding displayed.	Exceptional insight displayed.
Together with their group, student created a model of their solution that clearly communicates their idea.				
Student participated in the testing of two other models in the classroom and wrote at least one tip for improvement for each.				
Student identified one way that their model could be improved and drew a sketch of the new idea.				
Together with their group, students created an improved model using the feedback they received and the new sketch they drew.				
Student showed reflective skills by filling out the self-assessment chart.				

Anecdotal notes based on teacher observation:

LESSON 8

Share Your Solution!

Curriculum Correlations

Ontario Science and Technology Standards

Grade 1: Understanding Structures and Mechanisms—
Materials, Objects, and Everyday Structures
2.5, 2.6

Ontario Language Arts Standards

Oral communication standards
1.2, 2.3, 2.4, 2.7

Next Generation Science Standards

K-2-ETS1-3.

Common Core State Standards

Speaking and Listening: Presentation of Knowledge and Ideas

CCSS.ELA-LITERACY.SL.1.4

CCSS.ELA-LITERACY.SL.1.5

CCSS.ELA-LITERACY.SL.1.6

Materials

- Pages 12-13 of *How Engineers Find Solutions (Engineering Close-Up)* or anchor chart of the engineering design process
- *Sharing My Solution Worksheet with Self-Assessment*
- *Share Your Solution Rubric*
- Whiteboard and markers
- Timer

Setting the Stage

Using pages 12-13 of *How Engineers Find Solutions*, review the engineering design process. Have a class discussion about how students used the engineering design process over the last few days or weeks to create a solution to a classroom waste problem. Ask students:

- How have you used the engineering design process to create a solution that reduces waste in our classroom?
- What steps worked well for you?
- What steps have not worked well for you?
- Why is the engineering design process useful for engineers who design solutions?

Remind students that now, they should have an improved solution based on the feedback they received from their classmates during the testing step of the design process. Teacher may need to give students 5-10 minutes to gather their improved models and make any final adjustments.

Explain that now, we will complete the final step of the engineering design process: communicating our solutions to our peers. Ask students:

- Why is it important to communicate our solutions with one another?
 - ▶ We can learn from others' ideas to create new solutions
 - ▶ We can avoid future problems by using new solutions
 - ▶ We can help make a difference in our classroom by learning about and using different solutions

Objectives

Students will:

- Present their solutions to the class using co-created success criteria.
- Reflect on their work through engineering design process and the solution they created.

Activity

Tell students that they will give a short, 5-minute presentation that communicates their solution to their peers. They will have the remainder of the current class period to plan their presentation, then presentations will be given during the next class.

Co-create success criteria for the presentations with the students. Some criteria could be:

- Group clearly shows the improved model of their solution to the class.
- Group explains how the solution will reduce the amount of waste the classroom created.
- Group explains the materials they chose for their solution and why they suit the purpose.
- Group explains how each part of the object or each step in the process works together.
- Group uses scientific vocabulary in their presentation, such as:
 - ▶ Materials
 - ▶ Solution
 - ▶ Model
 - ▶ Waste
 - ▶ Heavy
 - ▶ Light
 - ▶ Flexible
 - ▶ Rigid
 - ▶ Hard
 - ▶ Soft
- Group uses appropriate vocal tone, pace, pitch, and volume to clearly explain solution.
- Presentation is approximately 5 minutes long.

Hand students *Sharing My Solution Worksheet*—1 per student. This worksheet assists students in planning their presentations using sentence starters and a checklist with the success criteria.

In the next class period, have each group present their solutions. Use the timer to assess the length of the presentations.

Extensions

- When each presentation is complete, give students 5 minutes to come up with one question about the group's solution. Invite 2 or 3 students to share their questions and give groups the opportunity to answer.
- Try it! Over multiple weeks or months, implement each solution in the classroom. Reflect on how each solution worked.

Wrap-Up

When the presentations are complete, have a short class discussion that reflects on the engineering design process. Ask students:

- How was the engineering design process useful in helping to create a solution to our classroom waste problem?
- What worked well? What would you change for next time?
- Do you think we have the solutions we need to reduce the amount of waste we create in the classroom?

Assessment

Use *Share Your Solution Rubric* to assess student's presentation and their solution.

Name: _____ Date: _____

Sharing My Solution Worksheet

Our solution to the classroom waste problem is _____

Our solution will help reduce the amount of waste our classroom creates by/because _____

The materials we chose for our solution are _____

We chose these materials because _____

The parts of our object work together by/The steps in our process work together by _____

Did I...	Yes	No
Plan to use scientific vocabulary to describe my solution and materials? • Materials, hard, soft, flexible, rigid, heavy, light, model, solution		
Plan to use the appropriate speed and volume while speaking?		
Plan a presentation that is 5 minutes long?		
Clearly explain my solution, how it solves the problem, and how I chose materials that work well together?		

Name: _____ Date: _____

Share Your Solution Rubric

Name of solution: _____

Level 1	Level 2	Level 3	Level 4
Student does not use scientific vocabulary.	Student uses a limited amount of appropriate scientific vocabulary.	Student uses an adequate amount of appropriate scientific vocabulary.	Student uses a high amount of appropriate scientific vocabulary.
Student does not speak with appropriate pacing and volume. Student is difficult to understand.	Student speaks with some pacing and volume challenges. Most of the student's speech can be clearly understood.	Student speaks with appropriate pace and volume so that they can be clearly understood.	Student speaks comfortably with appropriate pace and volume, and engages audience as well as being clearly understood.
Student does not show an appropriate level of comprehension when speaking about their group's solution, the materials chosen, and how it works.	Student shows a limited level of comprehension when speaking about their group's solution, the materials chosen, and how it works.	Student shows an appropriate level of comprehension when speaking about their group's solution, the materials chosen, and how it works.	Student shows an exceptional level of comprehension when speaking about their group's solution, the materials chosen, and how it works.
Student did not participate in presentation and did not contribute to the completion of assigned work.	Student does not participate equally in the group presentation—either by speaking too much, overpowering group members, or speaking too little. Student completes less than their share of assigned work.	Student participates equally in group presentation and completes their share of assigned work.	Student participates equally in group presentation and completes their share of assigned work, and takes a leadership role in the planning stages of the group work.