PictureSTEM

Designing Toy Box Organizers

PURDUE UNIVERSITY

INSPIRE
Research Institute for Pre-College Engineering

IOWA STATE UNIVERSITY

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About PictureSTEM
The PictureSTEM Project includes an instructional unit at each grade level, K-2, which employs engineering and literary contexts to integrate science, technology, mathematics, and computational thinking content instruction in meaningful and significant ways. These transformative new models for STEM+C (science, technology, engineering, mathematics, and computational thinking) learning use picture books and an engineering design challenge to provide students with authentic, contextual activities that engage learners in specific science, mathematics, and computational thinking content while integrating across traditional disciplinary boundaries. These units have been classroom tested and research has been published and is ongoing regarding student learning and teacher implementation in the classroom.

To learn more about the PictureSTEM Project and to view additional integrated STEM units, contact us:

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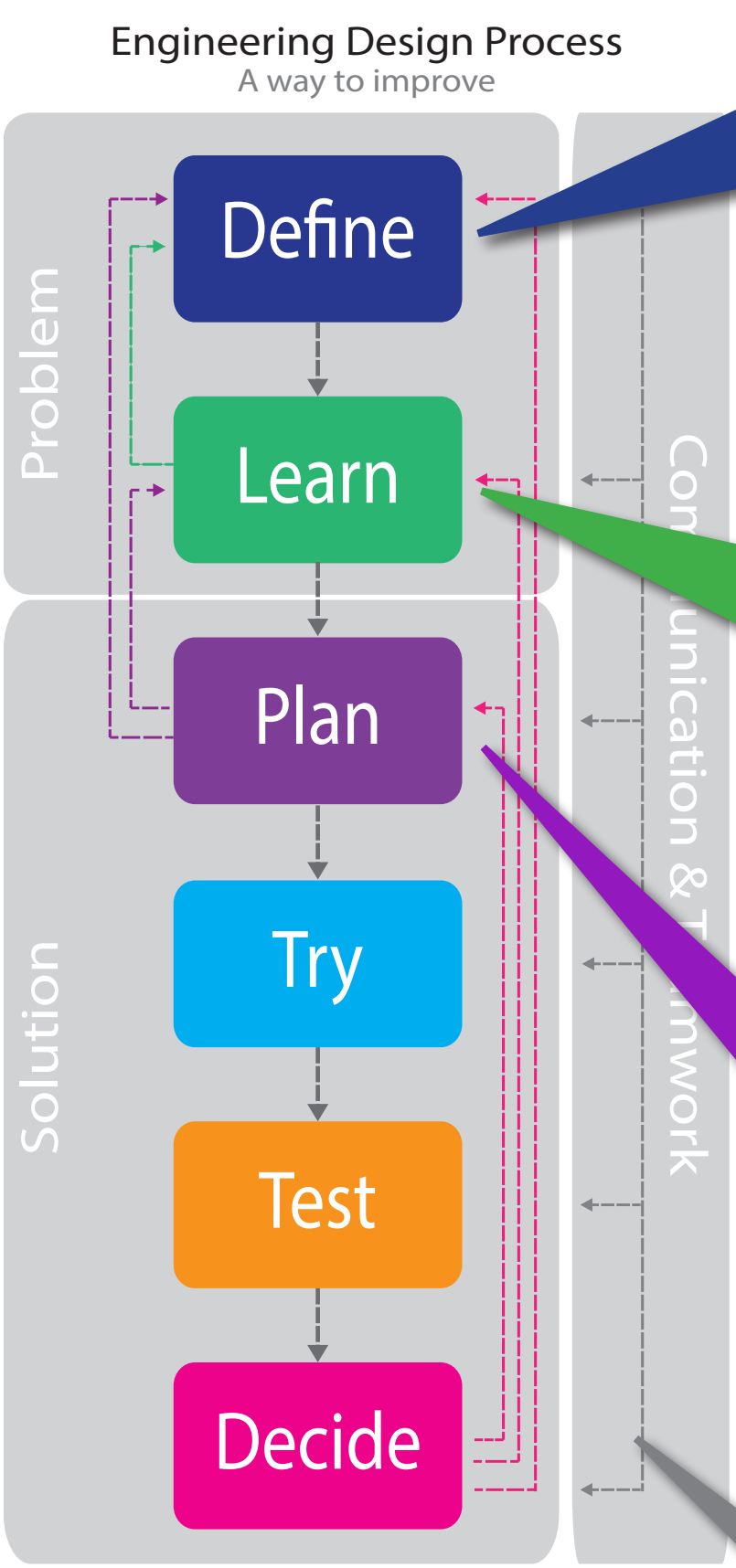
Overview: Engineering Design Process



DEFINE THE PROBLEM

- Who is the **client**?
- What does the client need?
- Why does the client need it?
- Who is the **end user**?
- Why might the end user want it?
- What are the **criteria** (requirements and limits) of the solution?

Problem Scoping:
WHO needs **WHAT** because **WHY**

LEARN ABOUT THE PROBLEM

- What kind of background knowledge is needed?
  - What science/math knowledge will be needed?
  - What materials will be needed?
- What has already been done to solve the problem?
- What products fill a similar need?
- How should we measure success and improvement?

PLAN A SOLUTION

- Continue to specify the criteria
- Generate ideas of possible solutions
- Develop multiple solution paths
- Consider **trade-offs** (criteria that compete with one another)
- Choose a solution to try
- Develop plans (blueprints, schematics, cost sheets, storyboards, notebook pages, etc.)

COMMUNICATION

- Communicate the solution clearly and make sure it is easily understandable
- Use **evidence** to support why the client should use your solution

Overview: Engineering Design Process

TRY A SOLUTION

- Put the plan into action
- Consider risks and how to optimize work
- Use criteria and consider trade-offs from the problem/plan to build a **prototype** (a testable representation of a solution), **model**, or **product**

TEST A SOLUTION

- Consider testable questions or hypotheses
- Develop experiments or rubrics to determine if the solution is meeting the stated criteria and needs
- Collect and analyze data

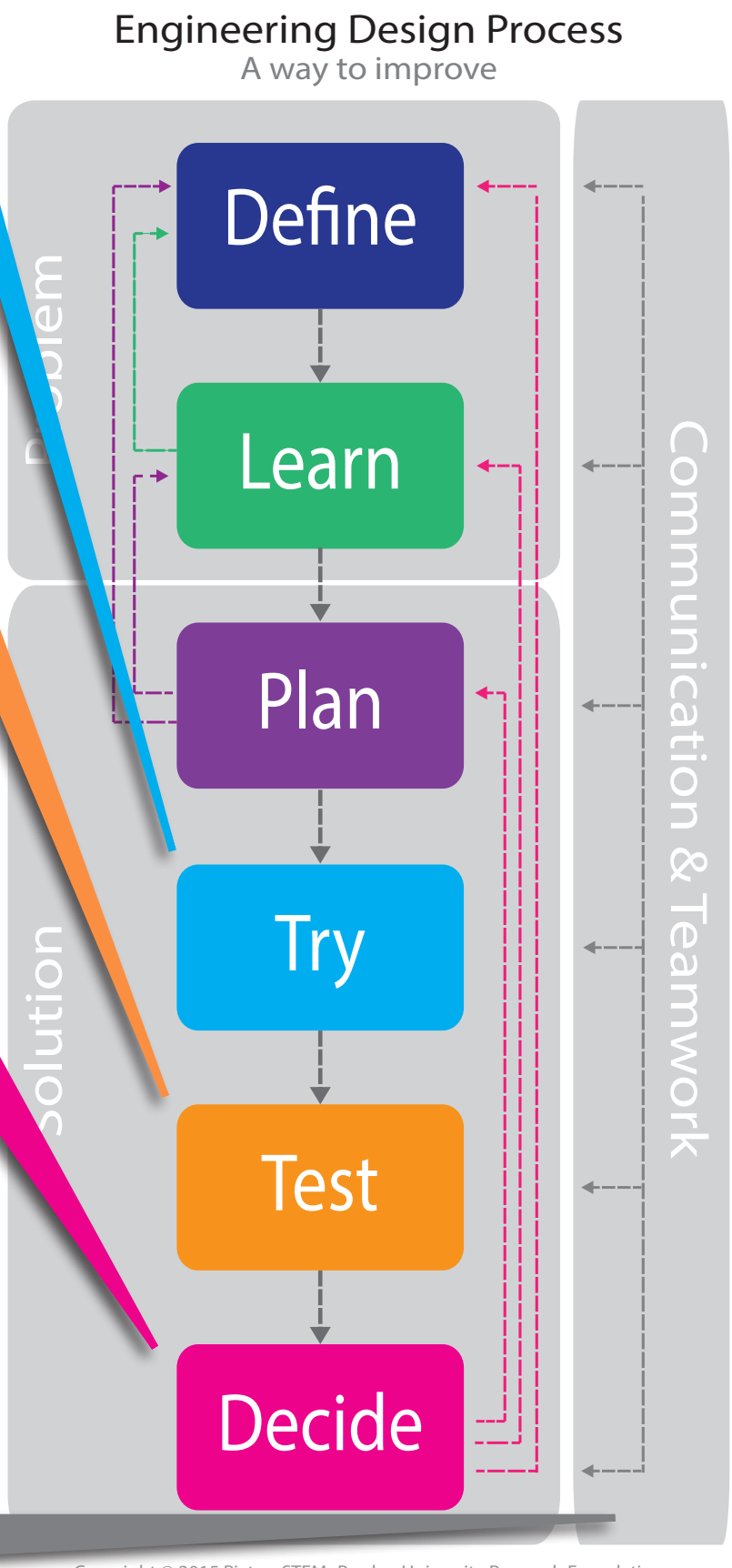
DECIDE IF THE SOLUTION IS GOOD ENOUGH

- Are users able to use the design to help with the problem?
- Does the design meet the criteria?
- How could the design be improved based on test results and feedback from the client/user?

Iterative nature of design: Always consider which step should be next!

TEAMWORK

- Discuss in teams how the solution meets the criteria and needs of the client
- Consider different viewpoints from each teammate



Overview: Unit Description

Grade Levels

Grades K-2

Approximate Time Needed to Complete Unit (see unit overview for breakdown)

- Introduction: one 50 minute class period or three 15-20 minute class periods
- Literacy: six 25-35 minute class periods
- STEM+C: six 45-90 minute class periods

Unit Summary

Talia's Toy Box Company has received complaints from parents about how messy toy boxes can get and how hard it is for their children to find their toys without dumping out all of the toys. In this unit, students investigate standard units of measure and sort objects according to their physical properties before applying them to design a toy box organizer.

Subject Level Connections

- **Science Connections:** Sort and describe materials by physical properties, conduct fair tests
- **Technology & Engineering Connections:** Create a toy box organizer design plan, follow the engineering design process
- **Mathematics Connections:** Learn about standard and non-standard units, use tools to measure length
- **Literacy Connections:** Use story structure to identify key details, compare and contrast story details, identify the main purpose of a text, name cause effect events from a story, summarize narrative text
- **Computational Thinking Connections:** Follow and develop algorithms for thinking about sequencing of events and accomplishing tasks

Standards Alignment - National Standards

Next Generation Science Standards

Matter and Its Interactions

- **2-PS1-1.** Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

Engineering Design

- **K-2-ETS1-1.** Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
- **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.
- **K-2-ETS1-3.** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Science and Engineering Practices

- **Practice 1:** Asking Questions and Defining Problems
- **Practice 2:** Developing and Using Models
- **Practice 3:** Planning and Carrying Out Investigations
- **Practice 4:** Analyzing and Interpreting Data
- **Practice 5:** Using Mathematics and Computational Thinking
- **Practice 6:** Constructing Explanations and Designing Solutions
- **Practice 7:** Engaging in Argument from Evidence
- **Practice 8:** Obtaining, Evaluating, and Communicating Information

Common Core State Standards - Mathematics

Measurement

- **2.MD.A.1** Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.
- **2.MD.A.2** Measure the length of an object twice, using length units of different lengths for the two measurements; describe how the two measurements relate to the size of the unit chosen.
- **2.MD.A.4** Measure to determine how much longer one object is than another, expressing the length difference in terms of a standard length unit.

Geometry

- **2.G.A.2** Partition a rectangle into rows and columns of same-size squares and count to find the total number of them.
- **2.G.A.3** Partition circles and rectangles into two, three, or four equal shares, describe the shares using the words halves, thirds, half of, a third of, etc., and describe the whole as two halves, three thirds, four fourths. Recognize that equal shares of identical wholes need not have the same shape.

Mathematics Process Standards

- **MP1** Make sense of problems and persevere in solving them.
- **MP2** Reason abstractly and quantitatively.
- **MP3** Construct viable arguments and critique the reasoning of others.
- **MP4** Model with mathematics.
- **MP5** Use appropriate tools strategically.

Common Core State Standards - English/Language Arts

Reading: Informational Text

Key Ideas and Details

- **RL.2.1** Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text.
- **RL.2.2** Recount stories, including fables and folktales from diverse cultures, and determine their central message, lesson, or moral.
- **RL.2.3** Describe how characters in a story respond to major events and challenges.

Craft and Structure

- **RI.2.6** Identify the main purpose of a text, including what the author wants to answer, explain, or describe.

Integration of Knowledge and Ideas

- **RI.2.7** Explain how specific images (e.g., a diagram showing how a machine works) contribute to and clarify a text.

Speaking & Listening

Comprehension and Collaboration

- **SL.2.1** Participate in collaborative conversations with diverse partners about grade 2 topics and texts with peers and adults in small and larger groups.
- **SL.2.1.A** Follow agreed-upon rules for discussions (e.g., gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion).
- **SL.2.1.B** Build on others' talk in conversations by linking their comments to the remarks of others.
- **SL.2.1.C** Ask for clarification and further explanation as needed about the topics and texts under discussion.
- **SL.2.2** Recount or describe key ideas or details from a text read aloud or information presented orally or through other media.
- **SL.2.3** Ask and answer questions about what a speaker says in order to clarify comprehension, gather additional information, or deepen understanding of a topic or issue.

Presentation of Knowledge and Ideas

- **SL.2.4** Tell a story or recount an experience with appropriate facts and relevant, descriptive details, speaking audibly in coherent sentences.
- **SL.2.6** Produce complete sentences when appropriate to task and situation in order to provide requested detail or clarification.

Overview: Unit Description

Computer Science Teachers Association K-12 Computer Science Standards

Algorithms and Programs

Developing and Using Abstractions

- **1A-A-4-4** Use numbers or other symbols to represent data (e.g., thumbs up/down for yes/no, color by number, arrows for direction, encoding/decoding a word using numbers or pictographs).

Recognizing and Defining Computational Problems

- **1A-A-3-6** Categorize a group of items based on the attributes or actions of each item, with or without a computing device.
- **1A-A-3-7** Construct and execute algorithms (sets of step-by-step instructions) that include sequencing and simple loops to accomplish a task, both independently and collaboratively, with or without a computing device.

Standards Alignment - Indiana Academic Standards

Science Standards

Physical Science

- **2.PS.1** Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
- **2.PS.4** Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

Engineering

- **K-2.E.1** Pose questions, make observations, and obtain information about a situation people want to change. Use this data to define a simple problem that can be solved through the construction of a new or improved object or tool.
- **K-2.E.2** Develop a simple sketch, drawing, or physical model to illustrate and investigate how the shape of an object helps it function as needed to solve an identified problem.
- **K-2.E.3** Analyze data from the investigation of two objects constructed to solve the same problem to compare the strengths and weaknesses of how each performs.

Science and Engineering Process Standards

- **SEPS.1** Posing questions (for science) and defining problems (for engineering).
- **SEPS.2** Developing and using models and tools.
- **SEPS.3** Constructing and performing investigations.
- **SEPS.4** Analyzing and interpreting data.
- **SEPS.5** Using mathematics and computational thinking.
- **SEPS.6** Constructing explanations (for science) and designing solutions (for engineering).
- **SEPS.7** Engaging in argument from evidence.
- **SEPS.8** Obtaining, evaluating, and communicating information.

Mathematics Standards

Geometry

- **2.G.4:** Partition a rectangle into rows and columns of same-size (unit) squares and count to find the total number of same-size squares.
- **2.G.5:** Partition circles and rectangles into two, three, or four equal parts; describe the shares using the words halves, thirds, half of, a third of, etc.; and describe the whole as two halves, three thirds, four fourths. Recognize that equal parts of identical wholes need not have the same shape.

Measurement

- **2.M.3:** Understand that the length of an object does not change regardless of the units used. Measure the length of an object twice using length units of different lengths for the two measurements. Describe how the two measurements relate to the size of the unit chosen.

Mathematics Process Standards

- **PS.1:** Make sense of problems and persevere in solving them.
- **PS.2:** Reason abstractly and quantitatively.
- **PS.3:** Construct viable arguments and critique the reasoning of others.
- **PS.4:** Model with mathematics.
- **PS.5:** Use appropriate tools strategically.
- **PS.7:** Look for and make use of structure.

English/Language Arts Standards

Reading: Literature

Learning Outcome

- **2.RL.1** Read and comprehend a variety of literature within a range of complexity appropriate for grades 2-3.
- By the end of grade 2, students interact with texts proficiently and independently at the low end of the range and with scaffolding as needed at the high end.

Key Ideas and Textual Support

- **2.RL.2.1** Ask and answer questions (e.g., who was the story about; why did an event happen; where did the story happen) to demonstrate understanding of main idea and key details in a text.
- **2.RL.2.3** Describe how characters in a story respond to major events and how characters affect the plot.
- **2.RL.2.4** Make predictions about the content of text using prior knowledge of text features, explaining whether they were confirmed or not confirmed and why.

Structural Elements and Organization

- **2.RL.3.1** Describe the overall structure of a story, including describing how the beginning introduces the story and the ending concludes the action.

Synthesis and Connection of Ideas

- **2.RL.4.1** Use information gained from the illustrations and words in a print or digital text to demonstrate understanding of its characters, setting, or plot.

Reading: Nonfiction

Key Ideas and Textual Support

- **2.RN.2.1** Ask and answer questions about the main idea and supporting facts and details in a text to confirm understanding.
- **2.RN.2.2** Identify the main idea of a multiparagraph text and the topic of each paragraph.
- **2.RN.2.3** Describe the connection between a series of historical events, scientific ideas or concepts, and steps in a process or procedure in a text.

Structural Elements and Organization

- **2.RN.3.2** Identify how a nonfiction text can be structured to compare and contrast, to describe a procedure, and to explain a cause and effect relationship.
- **2.RN.3.3** Identify what the author wants to answer, explain, or describe in the text.

Synthesis and Connection of Ideas

- **2.RN.4.1** Describe how an author uses facts to support specific points in a text.

Reading: Vocabulary

Learning Outcome

- **2.RV.1** Use words, phrases, and strategies acquired through conversations, reading and being read to, and responding to literature and nonfiction texts to build and apply vocabulary.

Vocabulary Building

- **2.RV.2.1** Use context clues (e.g., words and sentence clues) and text features (e.g., table of contents, headings) to determine the meanings of unknown words.

- **2.RV.2.5** Consult reference materials, both print and digital (e.g., dictionary), to determine or clarify the meanings of words and phrases.

Vocabulary in Literature and Nonfiction Texts

- **2.RV.3.1** Recognize that authors use words (e.g., regular beats, repeating lines, simile, alliteration, onomatopoeia, idioms) to provide rhythm and meaning in a story, poem, or song.

Speaking and Listening

Learning Outcome

- **2.SL.1** Listen actively and adjust the use of spoken language (e.g., conventions, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

Discussion and Collaboration

- **2.SL.2.1** Participate in collaborative conversations about grade-appropriate topics and texts with peers and adults in small and larger groups.
- **2.SL.2.2** Standard begins in third grade.
- **2.SL.2.3** Listen to others, take one's turn in respectful ways, and speak one at a time about the topics and text under discussion.
- **2.SL.2.4** Ask for clarification and further explanation as needed about the topics and texts under discussion.
- **2.SL.2.5** Build on others' talk in conversations by linking comments to the remarks of others

Comprehension

- **2.SL.3.1** Determine the purpose for listening (e.g., to obtain information, to enjoy humor) and paraphrase or describe key ideas or details from a text read aloud or information presented orally or through other media.
- **2.SL.3.2** Ask and answer questions about what a speaker says to clarify comprehension, gather information, or deepen understanding of a topic or issue.

Presentation of Knowledge and Ideas

- **2.SL.4.1** Using appropriate language, recite poems and rhymes, and tell a story or recount an experience, in an organized manner, with appropriate facts and careful attention to sensory details, speaking audibly in coherent sentences and at an appropriate pace.
- **2.SL.4.2** Create simple presentations that maintain a clear focus, using various media when appropriate to clarify ideas, thoughts, and feelings.
- **2.SL.4.3** Give and follow multi-step directions.

Computer Science Standards

Data and Information

- **K-2.DI.1** Use technology resources to solve age-appropriate problems and communicate thoughts, ideas, or stories in a step-by-step manner.
- **K-2.DI.2** Understand how to arrange (sort) information into useful order, such as sorting students by birth date, without using a computer.

Programs and Algorithms

- **K-2.PA.3** Arrange information using concept mapping tools and a set of statements that accomplish a simple task.

Overview: Lesson Summaries

Introduction Lesson - Defining the Problem: In this introductory lesson, students are introduced to the engineering challenge through letter/email interactions with their client. They will have the opportunity to explore the engineering design process, ask their client questions, help their client define the problem to be solved, and identify the criteria of the problem to be solved. Students also create a working definition of what an engineer is and what type of work they do.

Lesson 1A - *Henry's Map:* In this literacy lesson, students are introduced to the idea that a map is a way to communicate where things belong by reading *Henry's Map* by David Elliot. *Henry's Map* is a story about a pig who likes to be organized. When he realizes that the farm he lives on is out of sorts, he decides he will draw a map to get the farm organized. The focus for the activity that follows the story is on sequencing. Students use a sequencing mat and cards to put the main events from the story in the order they happened. This lesson builds background knowledge for the engineering design challenge and sets the stage for the related STEM+C activity (Lesson 1B). Reading strategy: sequencing.

Lesson 1B - Robot Mouse: In this STEM+C lesson, students learn how to read and create a map that communicates where objects belong. Students build on their knowledge about mapping and sequencing from Lesson 1A by exploring the Robot Mouse kit to see how it works. Students learn how to read the provided activity cards that serve as a map of what the mouse's course should look like. Students also must learn to create a flowchart of code, so they can program the mouse through the course maze. Finally, students are challenged to create an original activity card that the toy company can include in their new deck of cards. This lesson prepares students for the engineering design challenge in which they will have to draw a map for Talia to communicate where the organizer and toys should be placed in the toy box. Additionally, students will also be exposed to creating a plan, testing, and having to redesign in this activity.

Lesson 2A - Treasure Hunt: In this STEM+C lesson, students are introduced to the concept of standard and non-standard units. Students learn that there is a need for a common unit. In this lesson, they explore this idea through a modeling activity in which the students need to help Susie create a treasure map that can be followed by anyone regardless of their stride. After the problem is acted out for them, students work in pairs to come up with a solution for Susie. This lesson will help begin to build mathematical background knowledge about measurement that students will use to communicate information about their prototype to their client.

Lesson 2B - *How Big is a Foot?:* This literacy lesson reinforces the idea about the need for a standard unit of measurement that the students explored in the previous lesson with Susie's treasure hunt. The story *How Big is a Foot?* by Rolf Myller tells the story of a king who uses a non-standard measurement (his foot) to order a bed for his wife, the queen. Unfortunately, the bed makers' foot is a different size and so he ends up with the wrong size bed for the queen. This story introduces students to the idea that foot size varies between people, and, therefore, feet are not good units of measurement while working on identifying important ideas and details in the story. Students will use this mathematical knowledge when communicating their design solutions to their client. Reading strategy: using story structure to identify key details.

Lesson 3A - Standard vs Non-Standard Units: In the first part of this STEM+C lesson, students will measure a fixed distance, the inside of the Travel With Me Toy Box, using different arbitrary units. The teacher will collect and record each pair's measurement in a class data table. The idea is for students to further explore the concept of using different arbitrary units, and how that will produce different results when measuring a fixed object. In the second part, students will create a common or "standard" measuring tool as a class that they will use to measure the same fixed distance. This lesson continues to build mathematical knowledge students will use to communicate information about their design plan to their client.

Lesson 3B - *Measuring Penny:* In this literacy lesson, students will listen to a story titled *Measuring Penny* by Loreen Leedy, in which the main character, Lisa, decides to use her dog Penny as the subject for her measuring homework. This story helps to review what students have learned in the previous STEM+C lesson by exploring

multiple ways to measure a variety of objects while working on the comprehension skill of comparing and contrasting. Students continue to be introduced to the idea that there are different measuring units (standard and non-standard), as the main character explores a number of different measurements including length, weight, volume, time, temperature, and money. At the end of the activity, students will continue to develop their understanding of why standard units are important for measurement. This is a key mathematical concept students will use when creating and communicating their design plans. Reading strategy: comparing and contrasting.

Lesson 4A - *Living Color:* In this literacy lesson, the book *Living Color* by Steve Jenkins is used to explore different animals based on their color. While students learn about brightly colored species and the many purposes behind their coloring, this book also sets the stage for sorting objects using the physical property of color. This lesson serves as an introduction to the next STEM+C lesson where they will do a hands on exploration of physical properties. Reading strategy: identifying the main purpose of a text.

Lesson 4B - Investigating Properties: In this STEM+C activity, students learn about using physical properties to sort and describe different objects. In the first part of the lesson, students learn about size, shape, weight, texture, flexibility, and strength, and how these physical properties can be used to describe objects and the materials that they are made out of. After building some familiarity with these properties by sorting and describing a variety of objects, students will move into the second part of the activity, where they practice using these properties to describe an object in their mystery bag. Students will use this background knowledge to help them make choices about how they arrange the toys and which materials they will use to build their toy box organizer.

Lesson 5A - *Rosie Revere, Engineer:* In this literacy lesson, students learn about how failure should not be discouraging, but part of the process of engineering, while listening to *Rosie Revere, Engineer* by Andrea Beaty. This story is about Rosie, who dreams of becoming an engineer. Students will be able to identify the cause and effect of the main events and the central message, lesson, or moral of the story. This lesson is important, because students may experience failure during the testing process. Reading strategy: identifying the author's message.

Lesson 5B - Plan a Solution: In this STEM+C lesson, students will apply the science and mathematics knowledge they have learned in previous lessons to help them design a toy box organizer. First students will review the criteria and sort the toy box toys and building materials. Then they will create a design plan individually and then as a team.

Lesson 6A - *Too Many Toys:* In this literacy lesson, the teacher will read aloud *Too Many Toys* by David Shannon to help reinforce the context for why a parent and child might need a way to organize toys. The story is about Spencer, a little boy, who has too many toys. Spencer's mom finally has enough with all of his toys and tells him that he needs to clean up his toys and put some into a box to get rid of them. Reading strategy: summarizing narrative text.

Lesson 6B - A Solution for Talia: In this STEM+C lesson, students use their team design plan to build and test an organizer for their toy box. This is an important part of the engineering design process, as they find out what parts of their design work and what parts do not. After students share their designs and results, they will have the opportunity to redesign their toy box organizer. Finally, students will use what they learned and work on their communication skills to write a letter back to Talia explaining their solution to her toy box problem.

Overview: Unit Overview

Lesson	Activity Type	Time Needed	Materials
Introduction: Defining the Problem	STEM+C	50 min	• **Per student:** Engineering Design Process sliders • **Per class:** chart paper, markers, class poster of the Engineering Design Process, toy box with toys loose inside, 3 letters/emails from Talia
1A: *Henry's Map*	Literacy	30 min	• **Per student:** Sequencing the Story Mat (Version1 or 2), Sequencing Cards (Version 1 or 2), Engineering Design Process sliders • **Per class:** *Henry's Map* by David Elliot
1B: Robot Mouse	STEM+C	80 min	• **Per student:** Robot Mouse: Creating a Flowchart, Map It! worksheet, markers, colored pencils, or crayons, Engineering Design Process sliders
2A: Treasure Hunt	STEM+C	45 min	• **Per student:** Treasure Hunt - Help Find a Solution worksheet, Engineering Design Process sliders • **Per class:** Character Name tags, Map Location markers
2B: *How Big is a Foot?*	Literacy	30 min	• **Per student:** Story Structure graphic organizer, Engineering Design Process sliders • **Per class:** *How Big is a Foot?* by Rolf Myller
3A: Standard vs Non-Standard Units	STEM+C	50 min	• **Per student:** Measuring Tools worksheet, Engineering Design Process sliders • **Per pair:** Measuring tool bags with arbitrary units, common measuring tool, toy boxes, Grid Paper worksheet • **Per class:** Unit comparison chart, Talia's letters/emails
3B: *Measuring Penny*	Literacy	30 min	• **Per student:** Compare and Contrast worksheet, Engineering Design Process sliders • **Per class:** *Measuring Penny* by Loreen Leedy
4A: *Living Color*	Literacy	35 min	• **Per student:** What Does the Color Mean? graphic organizer, Engineering Design Process sliders • **Per class:** *Living Color* by Steve Jenkins
4B: Investigating Properties	STEM+C	45 min	• **Per student:** Physical properties bag • **Per pair:** Mystery bags • **Per class:** Physical Properties chart paper, markers, sticky notes
5A: *Rosie Revere, Engineer*	Literacy	25 min	• **Per student:** Cause and Effect graphic organizer, Engineering Design Process sliders • **Per class:** *Rosie Revere, Engineer* by Andrea Beaty
5B: Plan a Solution	STEM+C	90 min	• **Per student:** Individual Materials List, Individual Planning Sheet, Engineering Design Process sliders • **Per pair:** Team Materials lists, Team Planning sheets, toy box, set of toys, Sample Materials bags
6A: *Too Many Toys*	Literacy	30 min	• **Per student:** Summarizing the Story graphic organizer, Engineering Design Process sliders • **Per class:** *Too Many Toys* by David Shannon
6B: A Solution for Talia	STEM+C	90 min	• **Per student:** Planning and Materials sheets (from 5B), final letter/email to Talia, Engineering Design Process sliders • **Per pair:** Set of toys, toy box, building materials • **Per class:** Thank You letter/email, extra building materials, quality control cards, masking tape, camera, scissors

Overview: Unit Overview

Objectives The student will be able to:
• **Engineering:** learn engineers solve all kinds of problems. • **Engineering:** ask questions and obtain information about a problem that can be solved through the construction of a new tool.
• **Literacy:** use sequencing to retell main events in the story. • **Computational Thinking:** illustrate thoughts, ideas, and stories in a step-by-step manner.
• **Computational Thinking:** use technology to work cooperatively and collaboratively with peers to solve age-appropriate problems. • **Computational Thinking:** understand how to arrange information into a useful order.
• **Mathematics:** recognize that standard units are necessary to communicate distances/measurements to others.
• **Literacy:** identify key ideas and details in the story by asking and answering questions such as "who," "what," "when," "where," "why" and "how." • **Mathematics:** identify why it is important to use standard units of measurement when building an object.
• **Mathematics:** understand that different measuring units produce different results. • **Mathematics:** understand that for individuals to have an idea of the quantity or attribute measured there should be a common unit of measurement, "standard unit".
• **Literacy:** compare and contrast measurements. • **Science:** identify different attributes that were measured. • **Mathematics:** understand that attributes can be measured in different ways using either standard or non-standard units of measure.
• **Science:** recognize that living things are very diverse. • **Literacy:** identify the purpose of the text and the author's message. • **Literacy:** identify how images contribute to and clarify the text.
• **Science:** demonstrate an understanding of physical properties of objects by using these properties to sort and describe given objects with peers in collaborative conversations.
• **Literacy:** identify three cause-and-effect events from the story. • **Literacy:** recount stories and determine their central message, lesson, and moral. • **Engineering:** discuss the importance of testing materials before building a prototype.
• **Engineering:** investigate material's properties to determine how it will function to build a prototype. • **Literacy:** listen to others, explain, and take respectful turns while building on comments of others.
• **Literacy:** identify main events in the story, and how the main character responds to these events. • **Literacy:** summarize a story (narrative text) by identifying one sentence to represent the beginning, middle and end.
• **Engineering:** identify the problem and describe how their design solves the problem. • **Literacy:** participate in collaborative small group conversations, and give and follow multi-step directions. • **Engineering:** develop a drawing to illustrate how their prototype solves an identified problem. • **Engineering:** students analyze their prototypes and compare strengths and weaknesses of their first models and final models.

Master Material List

KEY
#S: number of students
#P: number of pairs
#G: number of groups
L: laminate

- 6 Books:
  - *Henry's Map* by David Elliot
  - *How Big is a Foot?* by Rolf Myller
  - *Measuring Penny* by Loreen Leedy
  - *Living Color* by Steve Jenkins
  - *Rosie Revere, Engineer* by Andrea Beaty
  - *Too Many Toys* by David Shannon
- 1 pack of large self-sticking chart paper (at least 6 pieces)
- 1 chart paper marker (for teacher)
- 1 roll of sticky back velcro 3/4 inch wide (for class poster of the Engineering Design Process)
- jumbo paper clips (for student Engineering Design Process sliders) (#S)
- toy box (#P + 1 extra box for educator)
- markers, colored pencils, or crayons (green, orange, yellow, blue, red, purple) (#S)
- Learning Essentials: STEM Robot Mouse Kit (we recommend groups of 2-4 students) (#G)
- camera or device to take photos of students' prototypes
- scissors (#P)
- 1 sandwich size plastic resealable bags (for quality control cards)
- 1 permanent marker (dark color)
- 1 roll of masking tape
- 8 sticky notes (3" x 3")
- 3 pieces of string (about 30")
- Single hole puncher
- Measuring Tool Bags:
  - sandwich size plastic resealable bags (#P)
  - arbitrary units (any manipulatives (plastic pennies, measuring worms, dominoes, centimeter cubes, counting chips, bear counters) you have in your classroom can be used) (#P)
- Common Measuring Tool Bag:
  - sandwich-size plastic resealable bags (#P)
  - common object (any object that has not already been used in the Measuring Tool Bags can be used; example: craft sticks) (#P)
- Physical Properties Bag: Note: Use the same two colors for the beads, large and small paper clips, felt, construction paper, and foam. For example, a blue and red paper clip and a blue and red large foam square. See Teacher Preparation Instructions Educator Resource in Lesson 4B for details.
  - sandwich-size plastic resealable bag (#S)
  - small feathers (one of the two colors used in the bag) (#S)
  - glass gem/vase fillers (clear or one of the two colors used in the bag) (#S)
  - craft beads (#S x 2)
  - large paper clips (#S x 2)
  - small paper clips (#S x 2)
  - felt (2.5" x 2.5") (#S x 2)
  - construction paper (2.5" x 2.5") (#S x 2)
  - foam (2.5" x 2.5") (#S x 2)
  - sandpaper (2.5" x 2.5") (#S)

  - pipe cleaners (2.5" long) (#S x 2)
  - mini craft stick (2.5" long); you can also cut a regular-sized craft stick to measure 2.5" (#S)
- Mystery Bag:
  - brown paper lunch sack (mini or regular size) (#P)
  - mystery item (use one of the toys from the toy box (#P)
- Set of toys for toy box:
  - gallon-size plastic resealable bags (#P)
  - toy car (#P)
  - Small building blocks (2-4 different sizes) (#P x 10)
  - golf ball (#P)
  - crayons (#P x 7)
  - bouncy ball (#P)
  - colored pencils (#P x 7)
  - mini paper notepad (#P)
  - sheet of stickers (#P)
  - beads (#P x 12)
  - mini playdough (#P)
  - large pink eraser (#P)
- Sample Materials Bags:
  - sandwich-size plastic resealable bag (#P)
  - aluminum foil (2.5" x 2.5") (#P)
  - pipe cleaner (2.5" long) (#P)
  - construction paper (2.5" x 2.5") (#P)
  - tissue paper (2.5" x 2.5") (#P)
  - string (2.5" long) (#P)
  - foam sheet (2.5" x 2.5") (#P)
  - mini craft stick (2.5" long) (#P)
- Building Materials: Note: Approximate amounts needed are shown below; actual amounts will be determined by students' plans and supply size.
  - aluminum foil (strips measure 12" x 1.75") (#P x 6 strips)
  - pipe cleaners (pipe cleaners measure 6mm x 12") (#P x 10 strips)
  - construction paper (strips measure 9" x 1.75") (#P x 6 strips)
  - tissue paper (strips measure 11.75" x 1.75") (#P x6 strips)
  - yarn (string cut to 20" long) (#P x 3 pieces)
  - foam sheets (strips measure 9" x 1.75") (#P x 6 strips)
  - craft sticks (stick measure 4.5" x 0.375") (#P x 12 sticks)

Master Printing List

KEY
#S: number of students
#P: number of pairs
#G: number of groups
L: laminate

Printable Manipulatives

- Engineering Design Process sliders (#S, L)
- 1 Engineering Design Process poster and large paper clip
- 1 First letter/email (L)
- 1 Second letter/email (L)
- 1 Third letter/email (L)
- Sequencing Cards (Version 1 or 2) (#S, L)
- Sequencing the Story (Version1 or 2) handout (#S, L)
- 1 Set of Character Name Tags (Susie, Brother, Dad) (L)
- 1 Set of Map Location Markers (big tree, swing set, garage, sidewalk) (L)
- 1 Large copy of Susie's Path (Version 1 or 2)
- 1 Large copy of Brother's Path (Version 1 or 2)
- 1 Large copy of Dad's Path (Version 1 or 2)
- 1 Large copy of All Paths (Version 1 or 2)
- 1 Deck of Quality Control Cards (L)
- 1 Thank You letter/email (L)

Student Handouts & Educator Resources

- Sequencing the Story (Version 1 and 2) Educator Resource
- 1 Robot Mouse Coding Activity Set: Activity Guide Educator Resource
- Robot Mouse: Creating a Flow Chart (#S)
- Robot Mouse: Creating a Flow Chart Educator Resource
- Map It! (#S)
- Map It! Educator Resource
- 1 The Treasure Hunt Problem Educator Resource
- Treasure Hunt - Help Find a Solution (#S)
- Story Structure (#S)
- Measuring tools (#S)
- Grid paper (#P)
- Compare and Contrast Measurements (#S)
- Compare and Contrast Measurements Educator Resource
- What Does the Color Mean? graphic organizer (#S)
- Lesson 4B Teacher Preparation Instructions Educator Resource
- Cause and Effect (#S)
- Individual Materials List (#S x 1 or 2)
- Individual Planning Sheet (#S x 1 or 2)
- Team Materials List (#P x 2)
- Team Planning Sheet (#P x 2)
- Summarize the Story (#S)
- Test Results (#S)
- Final letter/email to Talia (#S)

Lesson Intro

FOCUS/KEY CONCEPTS
Students will be able to:
- **Engineering:** learn engineers solve all kinds of problems.
- **Engineering:** pose questions and obtain information about a problem that can be solved through the construction of a new tool.

STANDARDS
National
- NGSS: K-2-ETS1-1
- CCSS-ELA: SL.2.1, SL.2.2. A-C, RI.2.6

MATERIALS
- **Per student:** Engineering Design Process sliders
- **Per class:** chart paper, markers, class poster of the Engineering Design Process, 1 toy box with toys loose inside, 3 Letters/ Emails from Talia

TEACHER PREPARATION
- Prepare Engineering Design Process poster and sliders with paper clips (see educator resource for instructions)
- Write "Problem" and "Criteria" on chart paper.
- Create a messy toy box by placing a set of toys inside one of the toy boxes.

VOCABULARY
- **engineer** A person who uses mathematics, science, and creativity to solve problems to help people
- **criteria** Goals of the design problem

(continued on next page)

Defining the Problem

SUMMARY OF THE LESSON
In this introductory lesson, students are introduced to the engineering challenge through letter/email interactions with their client. They will have the opportunity to explore the engineering design process, ask their client questions, help their client define the problem to be solved, and identify the criteria of the problem to be solved. Students also create a working definition of what an engineer is and what type of work they do.

INTRODUCTION
1. **Introduce engineering.** **Say:** *We are going to be working as engineers over the next few days.* **Ask:** *Does anyone know what an engineer does?* (Take student answers.) **Say:** *Engineers are people who use science, mathematics, and creativity to solve problems to help people. Typically their solution is a new or improved technology or a process.*

2. **Make a personal connection.** Give an example of a problem that you have had and ask students to help you think of a solution. Then ask students to share a problem they might have or have had in the past. **Say:** *Those are some good problems, and just like that you are starting to think like engineers.*

3. **Make a personal connection to the challenge.** **Say:** *Think of something that gets messy.* **Ask:** *What challenges do you have when it is messy? What can you do to make it easier to find something in the mess? What solutions are there for making it less messy?*

4. **Introduce the engineering design process.** Display the engineering design process and have students place their engineering design cycle cards in front of them. NOTE: If this is a distraction, only use the poster. Explain that engineers use this process along with science, mathematics, and creativity to understand a problem and create a solution. Have students move their paper clip on the EDP slider as you explain each step of the Engineering Design Process.
   - **DEFINE:** Engineers must define the problem and criteria (goals and limits).
   - **LEARN:** To better understand the problem, engineers must learn about the science and other factors that impact how the problem can be solved. As they learn, they must keep the problem and its goals and limits in mind.
   - **PLAN:** Engineers brainstorm many ideas before deciding which one to try. They must make plans that clearly communicate their idea. Plans may include some of the following information in word and/or picture form: measurements, materials, colors, how things fit together, and the order in which things should be done. Engineers must make sure that their plan meets the goals and limits presented in the problem as best as possible. While creating their plan, engineers may find they need to go back and learn something before their plan can be finalized.
   - **TRY:** Engineers use their plan to try to create a prototype of their planned solution. A prototype is a testable model used to test a design plan. Although a prototype allows the engineer to test

parts of their design, it is not the final solution or product. In fact, it may not even be the same size as the final design.

- **TEST:** Engineers test their plan to see if it is a good solution for the problem. Engineers must conduct fair tests and use mathematics to make sense of the data they collect.
- **DECIDE:** Engineers use the test results to make decisions about the solution. Does it solve the problem and meet the criteria (goals and limits)? Are there new things that need to be learned in order to better solve the problem? Should they try other ideas that were previously brainstormed or brainstorm new ideas to achieve a better solution?

5. **Introduce the problem.** Read **Talia's First Letter/Email**.

6. **Identify where they are in the engineering design process. (Define)** **Ask:** *Where do you think we are in the engineering design process?* (point to the classroom Engineering Design Process chart) *Why do you think so?* **Say:** *Engineers need to define the problem they will solve before they can learn about the problem, plan a design, try the design, test the design, and decide if their design works.*

ACTIVITY - Defining the problem

7. **Define the problem.** **Say:** *Let's think back to the letter/email we received.* **Ask:** *Who is the client? What does the client need? Why does she need it? Who is the end-user (the person who will use the product being designed)?* (Record students' responses on the chart paper labeled "Problem.")

8. **Provide feedback to Talia.** **Ask:** *Do you have any questions for Talia about the Travel with Me Toy Box?* Record questions. **Ask:** *What are some of your ideas about how Talia can make her toy box neat, so kids can find their toys easily?* (Record students' responses.) You may need to develop answers to the students' questions that help them focus in on the problem and not be distracted by other ideas. Quickly help the class draft an email/letter to Talia and "send" it.
NOTE: This would be a good time to take a break (give time for Talia to "respond"). This will also help break up the introduction.

9. **More information about the engineering challenge.** Read the **Second Letter/Email from Talia's Toy Box Company**.

10. **Provide more feedback to Talia.** **Ask:** *What does Talia want the organizer to do?* (Record their responses.) **Ask:** *What other qualities would a good toy box organizer have?* (Add their answers to the list.) **Ask:** *How can we test the organizers to make sure that they have the things we put on our list?* (Record student responses. (e.g., Clean-up test: remove all of the toys and time how long it takes to put the toys back where they belong in the toy box. Adaptability test: provide several new toys and see if the organizer can change to include them.)) Help the class draft an email/letter to Talia and "send" it.
NOTE: This would be a good time to take a break (give time for Talia to "respond"). This will also help break up the introduction.

Lesson Intro

- **engineering design process** A series of phases engineers go through in designing products such as background of problem, designing and implementing a prototype, and evaluating and refining designed product
- **prototype** A testable model of a design
- **end-user** The person who will use the product being designed
- **chief executive officer (CEO)** Highest ranking leader who is responsible for managing the organization

Lesson Intro

Defining the Problem

11. **Even more information about the challenge.** Read the **Third Letter/ Email from Talia's Toy Box Company**.

12. **Define what an engineer is and what they do.** **Say:** *We are going to think like engineers while we work to design a toy box organizer.* Talk with students about what an engineer is and what they do. **Say:** *Engineers use mathematics, science, and creativity to solve problems to help people.*

13. **Identify the criteria and define "criteria."** **Say:** *In Talia's letters/emails, there are several things that she would like to be true about the toy box organizer. I'm going to read her letter/email again, raise your hand when you hear something that Talia wants to be true about the toy box organizer.* Read Talia's letter/email aloud again. Record students' responses on the chart paper. Note: The students should identify the Grab Test, Shake Test, student-created test(s), must fit and work inside the toy box, and the lid must be able to close with the organizer and toys inside. Point to the chart paper and **say:** *These things that you have said need to be true about the toy box organizer are called "criteria." Criteria are the goals of the design problem. They can be used to decide how good a solution is to the problem.*

CLOSURE

14. **Check in with students.** Encourage students to share any questions they may have about the problem or criteria. Record their questions on a sheet of chart paper. Share that engineers also ask questions about the problems they are trying to solve. Questioning helps engineers know what they need to learn more about and what kind of tests they must do before brainstorming a solution.

TEACHER NOTES

TALIA'S TOY BOX COMPANY

Dear Students,

Hi! My name is Talia Lukas and I am the owner and CEO of Talia's Toy Box Company.

My company makes many different toy boxes. The most popular one is the smallest, the Travel with Me Toy Box. It allows children to carry small toys with them when they are "on the go." Some parents complained about how messy the boxes can get. They say it is hard for kids to find the toy they want. Sometimes they have to dump out the entire box! People love the toy box but wish there was a way to keep the toys organized.

Can you please send me some ideas about how to keep the Travel with Me Toy Box neat? I want to help kids find their toys better.

Thank you for all of your help!

Sincerely,

Talia Lukas

Talia Lukas
CEO, Talia's Toy Box Company

1234 Toy Lane ■ West Lafayette, IN 47906 ■ Phone: 765-567-8910
Email: Talia@taliastoyboxco.com ■ www.TaliasToyBoxCo.com

TALIA'S TOY BOX COMPANY

Dear Students,

Thank you for your toy box ideas! I really liked them. I have decided to use an organizer to keep the toy box neat and to help make it easier for kids to find their toys.

I am not sure how to make a successful toy box organizer. I know I want the organizer to help keep toys where they are supposed to be and to make it easier for kids to find a particular toy without dumping out the entire box. There are probably other things that make a toy box organizer good.

Please help me think of what these other things are. I also need you to send me some ways to test the organizers to make sure that they are successful.

Thank you for all of your help!

Sincerely,

Talia Lukas

Talia Lukas
CEO, Talia's Toy Box Company

1234 Toy Lane ■ West Lafayette, IN 47906 ■ Phone: 765-567-8910
Email: Talia@taliastoyboxco.com ■ www.TaliasToyBoxCo.com

TALIA'S TOY BOX
COMPANY

Dear Students,

Thank you for your ideas! I have decided that I want you to use three or four tests to help you know if your organizer prototype is successful:

1. The Grab Test: pick a card from the Quality Control card deck. Each Quality Control card has a picture of one of the test toys on it. You need to find all of the pieces of the toy and be ready to play with it in five seconds or less.
2. The Shake Test: place the lid on the toy box and shake it. The test toys should not move around the box.
3. Pick one or two of your own tests to get more information. How will you know if your design is successful?

As you plan your design, remember that the toy box organizer must fit inside the Travel with Me Toy Box. Also, the lid of the toy box must snap shut when the organizer and all of the test toys are inside.

Please send us four things:
1. A map for where the organizer and toys should be placed in the toy box.
2. A list with the materials you used.
3. A picture of your prototype.
4. The results of your tests.

Thank you for all of your help!
Talia Lukas
Talia Lukas
CEO, Talia's Toy Box Company

1234 Toy Lane ■ West Lafayette, IN 47906 ■ Phone: 765-567-8910
Email: Talia@taliastoyboxco.com ■ www.TaliasToyBoxCo.com

Delete | Reply | Reply All | Forward | Move | Related | Follow Up

From: Talia@taliastoyboxco.com
To: StudentEngineers@gmail.com
CC:
Subject: Toy Box Organizer Design Plan

Dear Students,

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My company makes many different toy boxes. The most popular one is the smallest, the Travel with Me Toy Box. It allows children to carry small toys with them when they are "on the go." Some parents complained about how messy the boxes can get. They say it is hard for kids to find the toy they want. Sometimes they have to dump out the entire box! People love the toy box but wish there was a way to keep the toys organized.

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Thank you for all of your help!

Talia Lukas
CEO, Talia's Toy Box Company

Delete | Reply | Reply All | Forward | Move | Related | Follow Up

From: Talia@taliastoyboxco.com
To: StudentEngineers@gmail.com
CC:
Subject: RE: Toy Box Organizer Design Plan

Dear Students,

Thank you for your toy box ideas! I really liked them. I have decided to use an organizer to keep the toy box neat. It will also make it easier for kids to find their toys.

I am not sure how to make a successful toy box organizer. I know I want the organizer to help keep toys where they should be. I also want to make it easier for kids to find their toys without dumping out the entire box. There are probably other things that make a toy box organizer good.

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4. The results of your tests.

Thank you for all of your help!

Talia Lukas
CEO, Talia's Toy Box Company

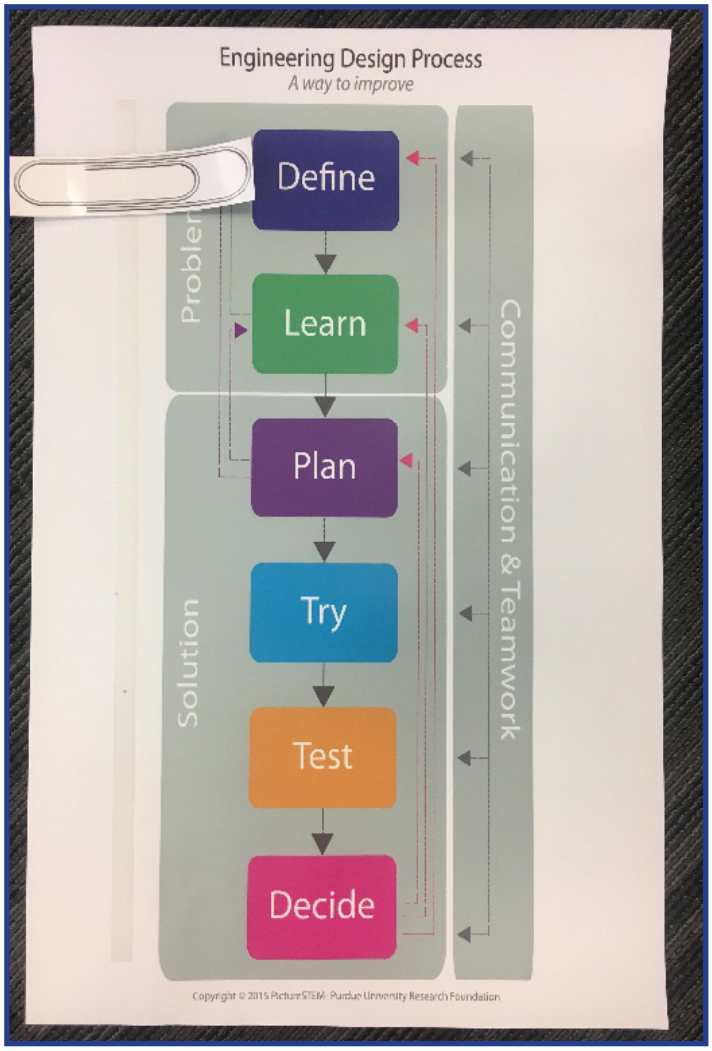
How to make EDP sliders

HOW TO CREATE THE POSTER

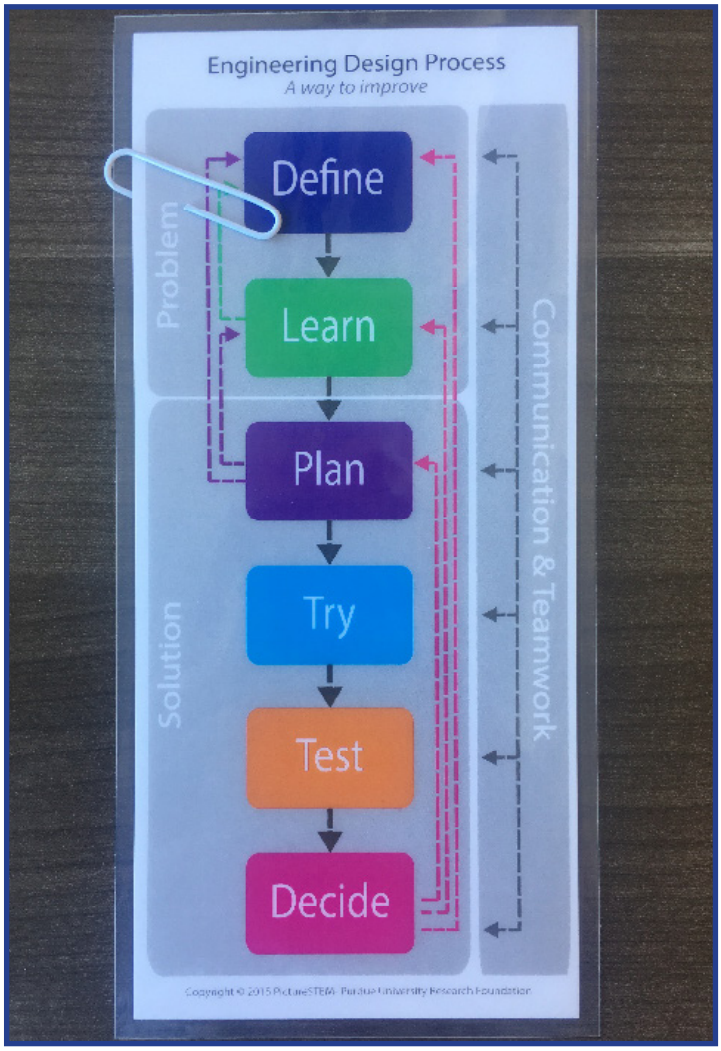
1. Download the high-quality PictureSTEM Slider Poster and the paper clip images from PictureSTEM.org.
2. Print out the poster and the paperclip on poster-sized paper and cut to size. High-gloss or semi-gloss paper is the best choice.
3. Use self-sticking velcro on the back of the paperclip and down the side of the poster so that the paperclip can be placed to point at all 6 sections of the slider.

HOW TO CREATE INDIVIDUAL SLIDERS

1. Print the sliders on the opposite page - enough for one slider per student in your class.
2. Cut the sliders apart.
3. Laminate the sliders individually.
4. Use a jumbo paper clip as the pointer for each slider.



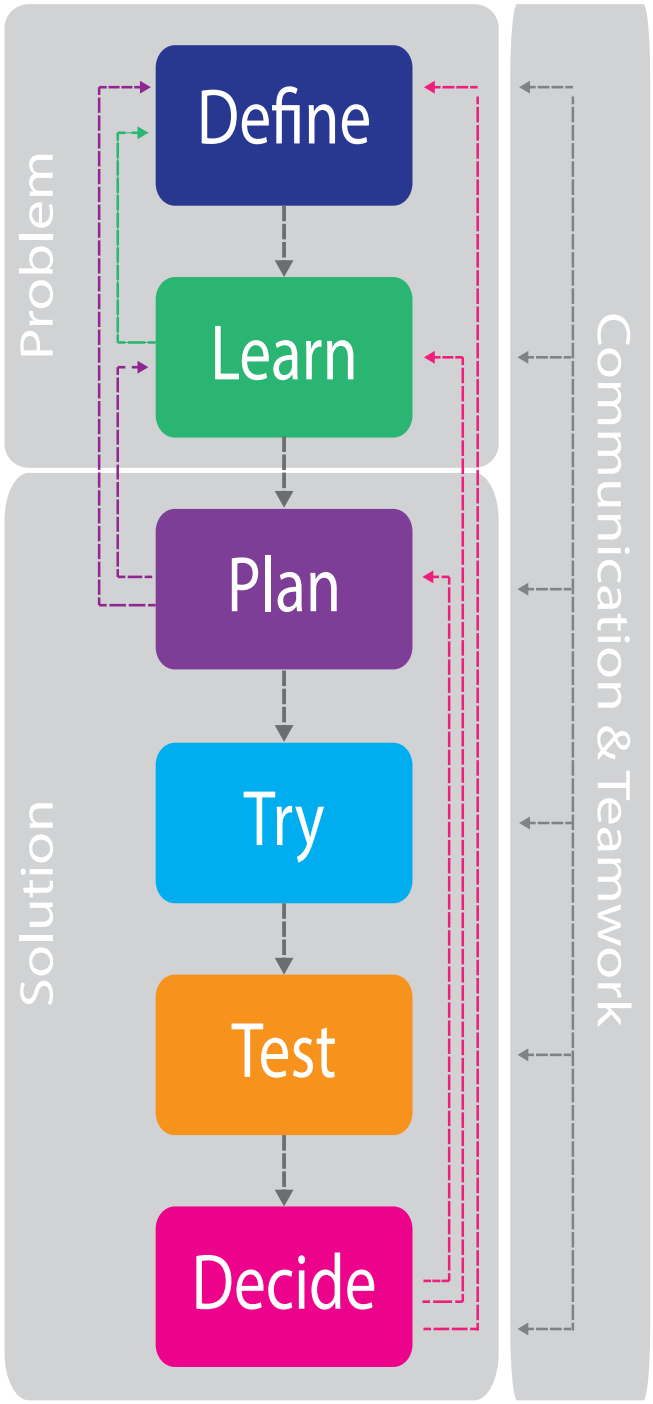
Poster



Individual slider

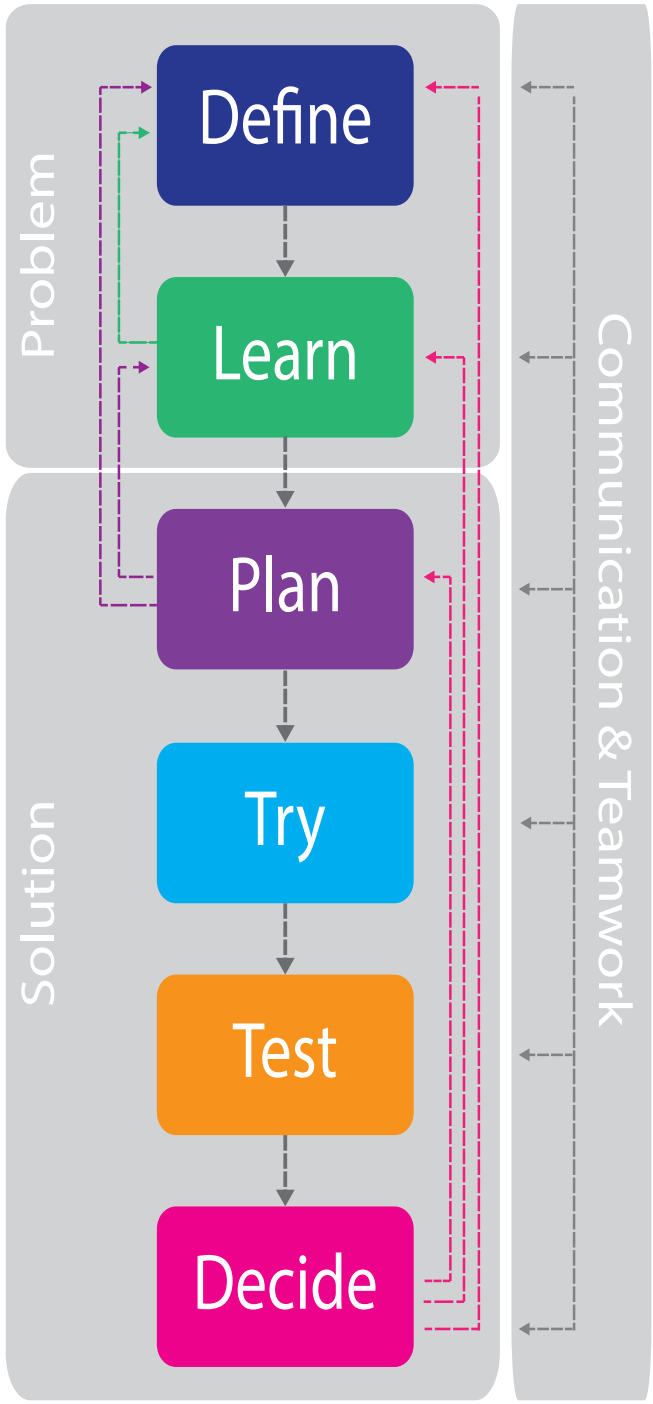
Engineering Design Process

A way to improve



Engineering Design Process

A way to improve



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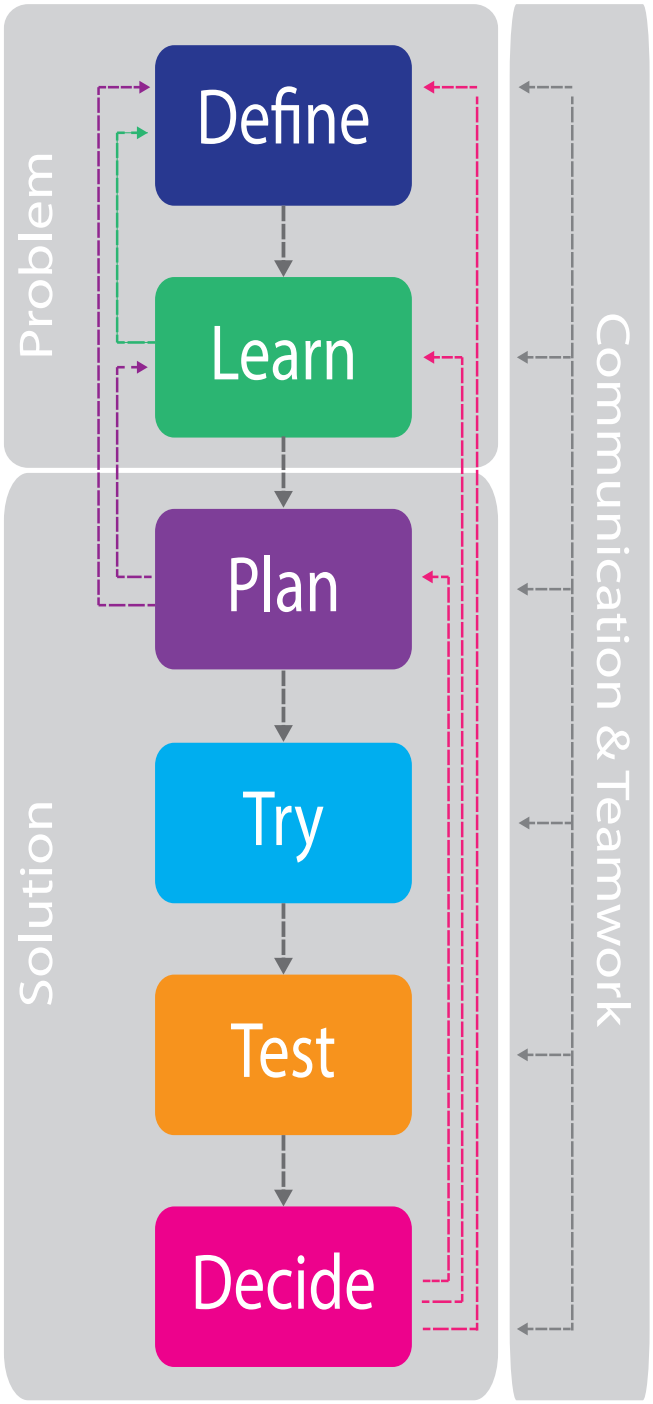
Engineering Design Process

A way to improve



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Lesson 1A

FOCUS/KEY CONCEPTS

Students will be able to:

- **Literacy:** use sequencing to retell main events in the story.
- **Computational Thinking:** illustrate thoughts, ideas, and stories in a step-by-step manner.

STANDARDS

National

- CCSS-ELA: RL.2.1, RI.2.7, LS.2.2
- CSTA: 1 A-A-4-4

MATERIALS

- **Per student:** Sequencing the Story Mat (Version1 or 2), Sequencing Cards (Version 1 or 2), Engineering Design Process sliders
- **Per class:** *Henry's Map* by David Elliot

TEACHER PREPARATION

- Laminate a class set of the Sequencing the Story mat.
- Cut and laminate a class set of the Sequencing Cards.

VOCABULARY

- **map** a visual representation (a picture or chart) that shows the position of different parts of something

Henry's Map

LESSON SUMMARY

In this literacy lesson, students are introduced to the idea that a map is a way to communicate where things belong by reading *Henry's Map* by David Elliot. *Henry's Map* is a story about a pig who likes to be organized. When he realizes that the farm he lives on is out of sorts, he decides he will draw a map to get the farm organized. The focus for the activity that follows the story is sequencing. Students use a sequencing mat and cards to put the main events from the story in order they happened. This lesson builds background knowledge for the engineering design challenge and sets the stage for the related STEM+C activity (Lesson 1B). Reading strategy: sequencing.

INTRODUCTION

1. **Tie to engineering challenge.** **Say:** *We received several letters/emails from Talia who needs our help. What does she need help with?* Create an organizer for their Travel with Me toy box to keep the toys organized. *How can we help her? What are some of the criteria that we need to keep in mind when designing the organizer?*

2. **Identify where they are in the engineering design process. (Learn).** **Ask:** *What phase are we on in the engineering design process?* (point to the Engineering Design Process chart) *Where should we move our paper clip? Why?* **Say:** *Like engineers, we want to make sure that we understand what the problem is and who we are solving it for. We also need to learn as much as we can about the problem and ways to solve the problem before we start on our designs. One of the important parts of our design is that the plan needs to show Talia where the organizer and toys should go. Today, we will learn about maps, and how they can help us communicate where something should go.*

3. **Connect to prior knowledge.** **Ask:** *If someone new wanted to come visit our classroom, and they were in the front office, how could we help them get here?* (Give them directions, show them the way.) *What if we were out at recess, is there a way they could get to the room on their own?* (Give them directions or a map.)

ACTIVITY - Sequencing

4. **Introduce the book.** **Say:** *Today we will read a story about a pig named Henry, who likes to be organized. He likes for everything to be in its place so that he and others can easily find things. One day Henry looks out his window and sees that the farm where he lives is a mess. He worries that no one will be able to find anything on the farm. So, Henry thinks of a plan. Let's see what happens to our friend Henry, and how he solves the messy farm problem.*

5. **Introduce/Explain the reading strategy.** **Say:** *Today we are going to continue to work on becoming better readers by practicing different skills that we can use to remember what happened in the story. Good readers use different strategies to make sure that they understand what they are reading, and one way to do that is using sequencing to put the main events in the order of how they*

happened in the story. This helps us better understand what we have read.

6. **Start reading.** Read the book out loud and remember to use some of the strategies that help with reading and comprehension development:
   - Teach new vocabulary at the point of contact.
   - Target the reading skill, sequencing, to help identifying main events from the story.
   - Encourage higher-level thinking and monitor comprehension by pausing for "teacher think alouds" and asking questions about or discussing the text.

7. **Re-read and practice.** Pass out the Sequencing the Story mats and Sequencing Cards. Have students recount the key details of the story by identifying and ordering the Sequencing Cards.
   Note: Point out how the mat does not always go from left to right. Before sequencing with the cards, have students use the arrows to guide them as they use their finger to trace over the path of the boxes.

CLOSURE

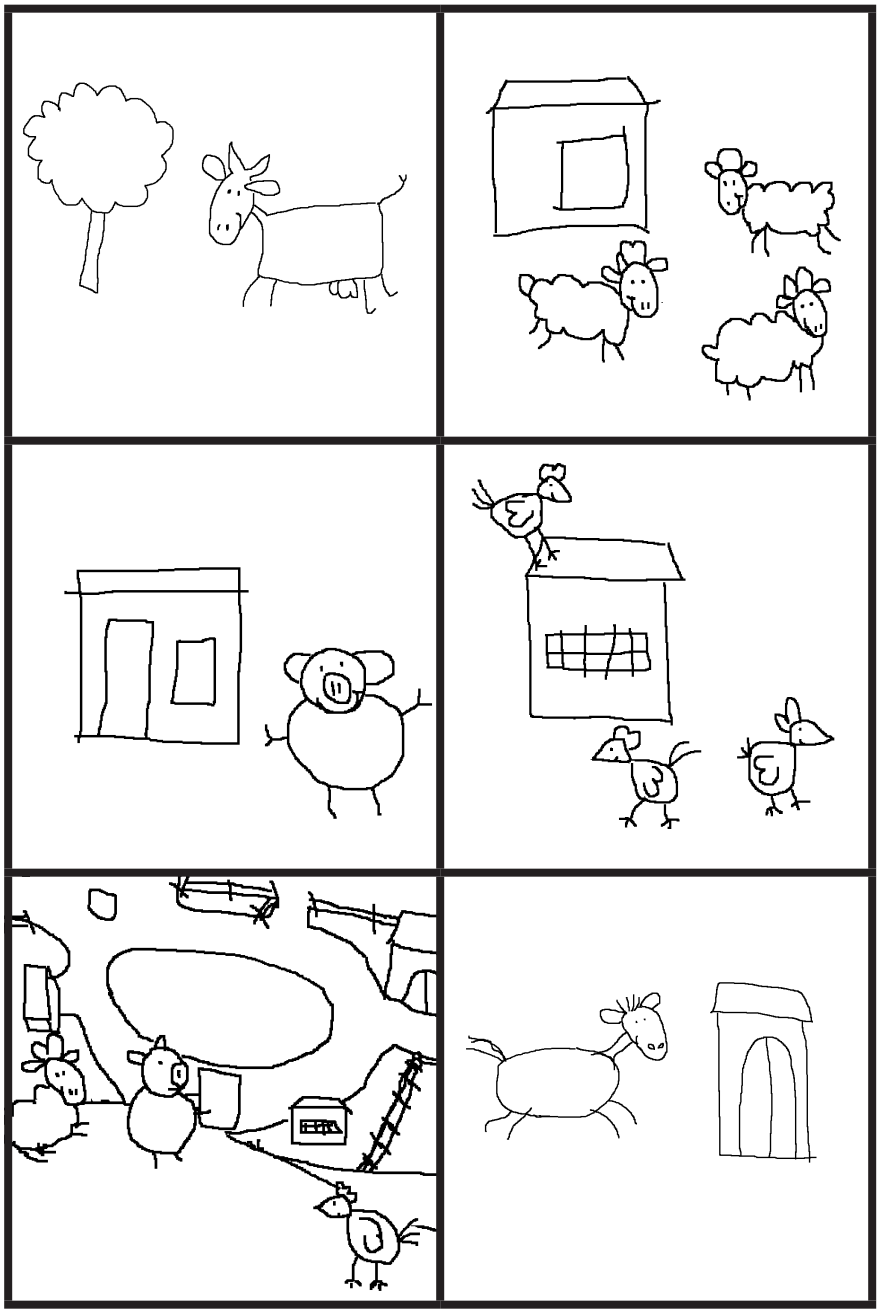
8. **Tie back to engineering challenge.** **Ask:** *How is Henry's problem similar to the problem that we will be solving?* (The farm is messy and he needs a way to keep the farm organized and we are helping to keep the toy boxes organized.) *How does Henry solve his problem? (*He makes a map.) *Do you think we could do that with our toy boxes? (*Yes, we could map where the organizer should go.*) Will a map be enough to keep the toys organized?* (No, a map alone will not keep the toys organized, but it might help people find things easier and be a good way to communicate our plan for the organizer to Talia.) **Say:** *In the next lesson, we are going to continue to think and learn about maps and what we need to do in order to make a map that someone else can follow.*

TEACHER NOTES

Lesson 1A

Sequencing Cards - Version 1

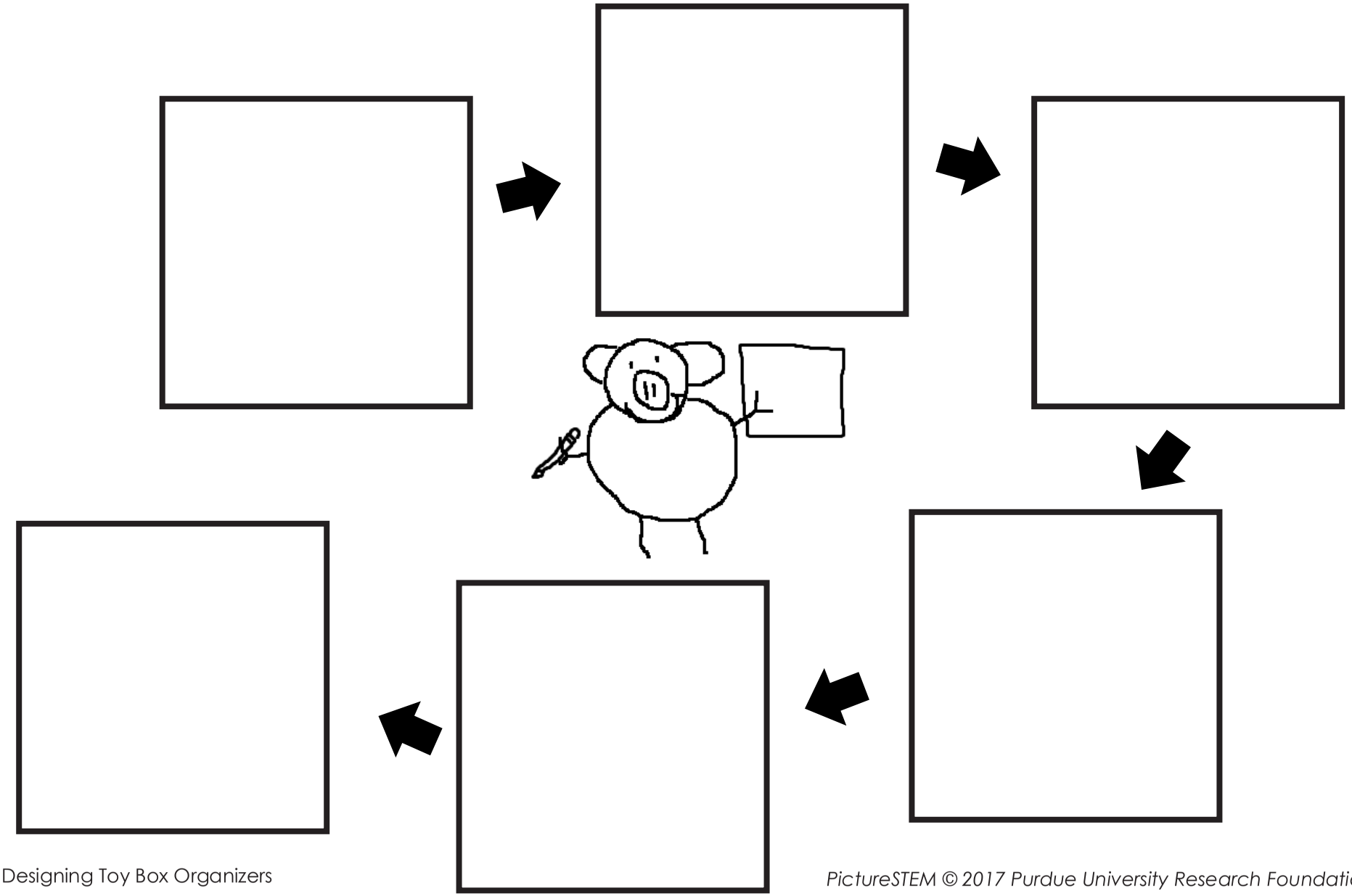
Directions: Cut out the sequencing cards. Laminate the cards and trim around the edges.



Lesson 1A

Sequencing the Story - Version 1

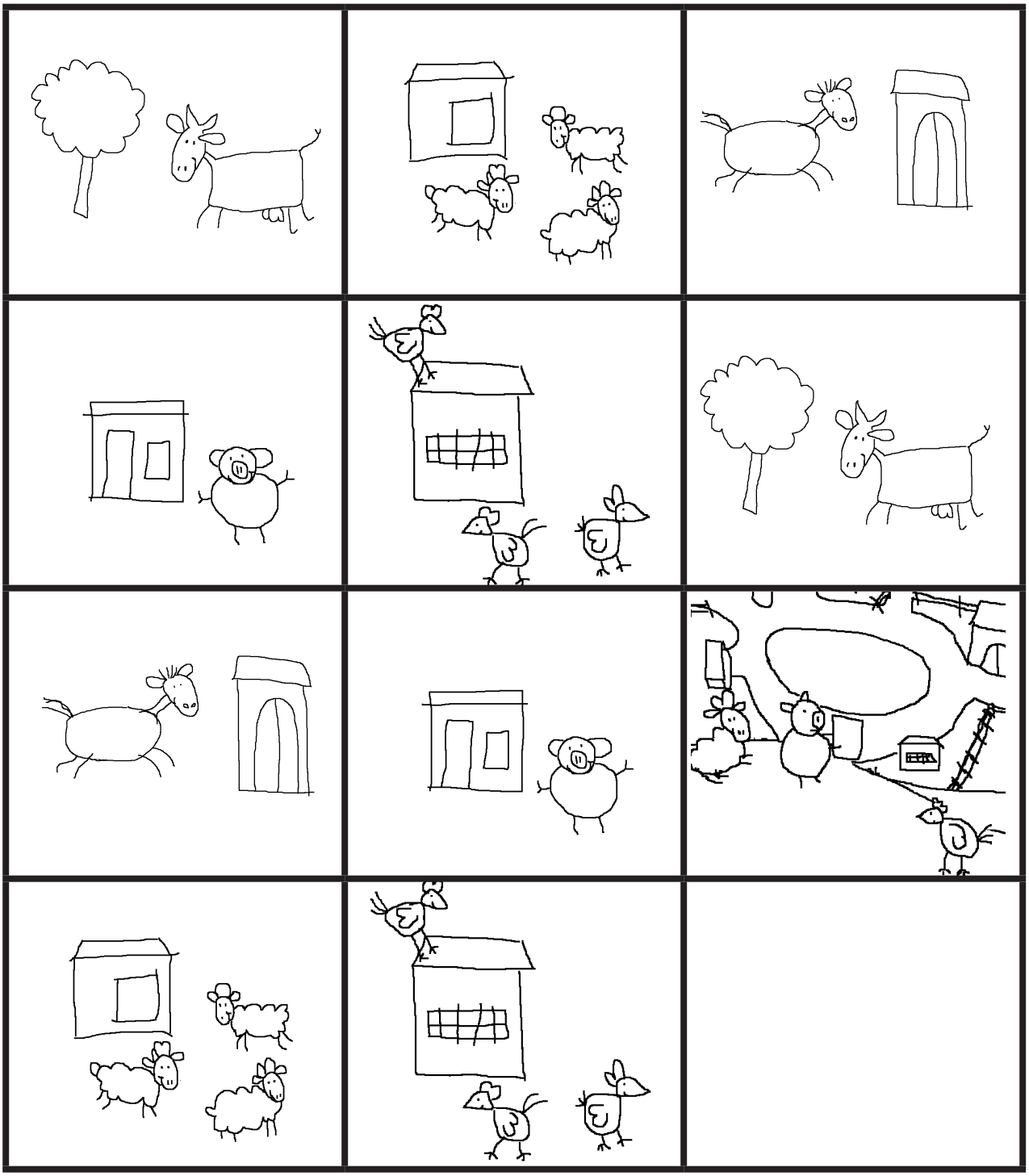
Directions: Place the Sequencing Cards on the flow chart below in the order they occurred in the story.



Lesson 1A

Sequencing Cards - Version 2

Directions: Cut out the sequencing cards. Laminate the cards and trim around the edges.



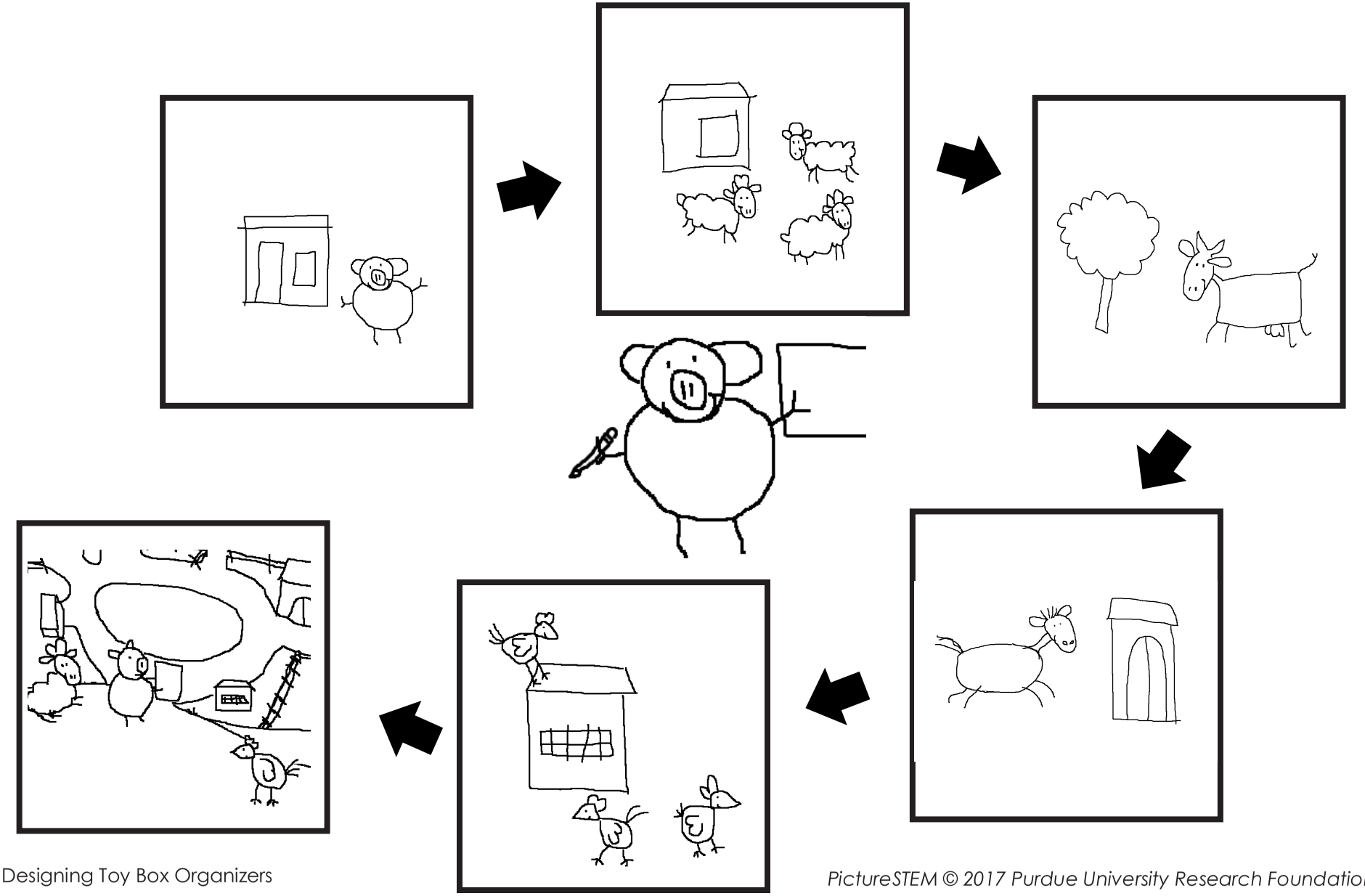
Lesson 1A

Sequencing the Story - Version 2

Directions: Place the Sequencing Cards on the flow chart below in the order they occurred in the story.

Lesson 1A Sequencing the Story - Version 1

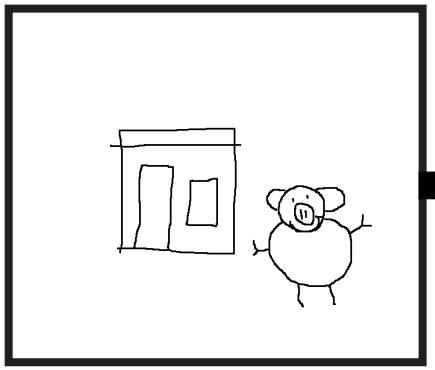
Directions: Place the Sequencing Cards on the flow chart below in the order they occurred in the story.

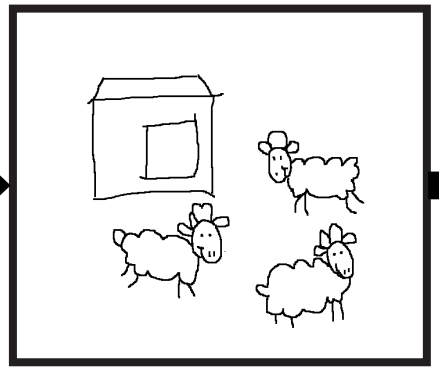


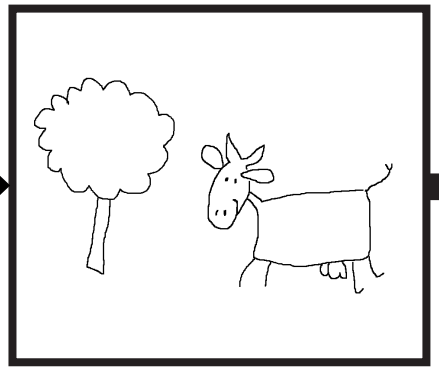
Lesson 1A

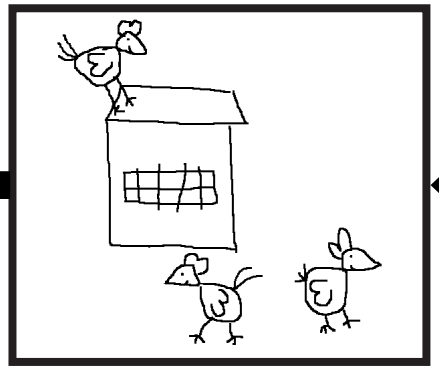
Sequencing the Story - Version 2

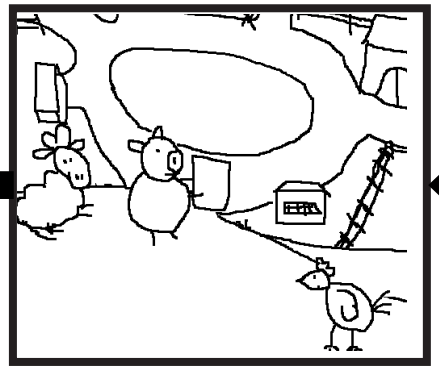
Directions: Place the Sequencing Cards on the flow chart below in the order they occurred in the story.

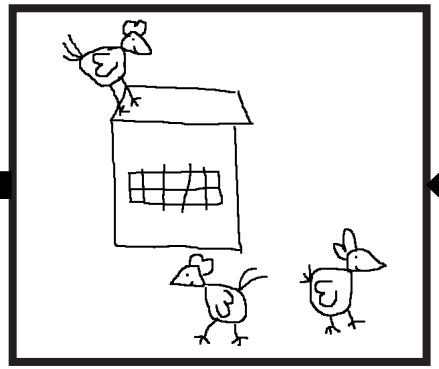


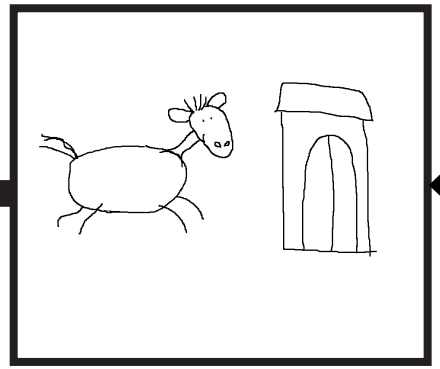


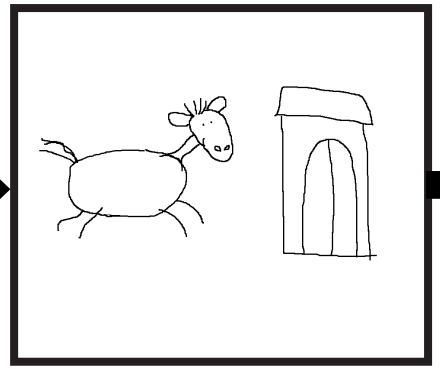


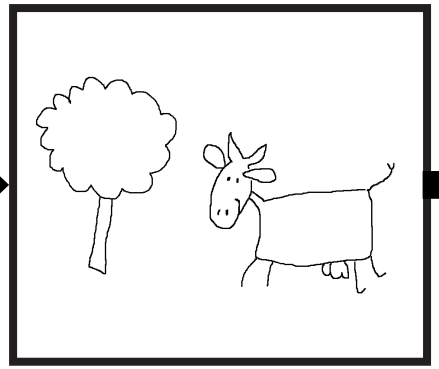


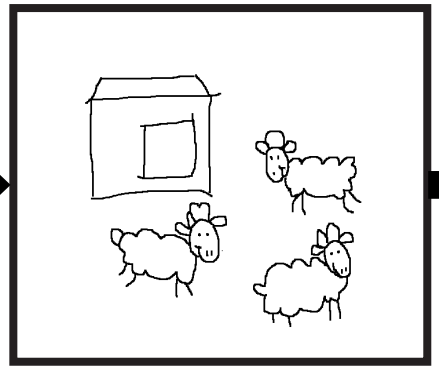


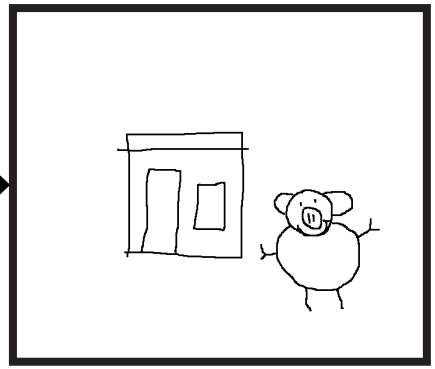












Lesson 1B

Robot Mouse

FOCUS/KEY CONCEPTS

Students will be able to:

- **Computational Thinking:** use technology to work cooperatively and collaboratively with peers to solve age appropriate problems.
- **Computational Thinking:** understand how to arrange information into a useful order.

STANDARDS

National

- CSTA: 1 A-A-4-4, 1 A-A-3-6, 1 A-A-3-7

MATERIALS

- **Per student:** Robot Mouse: Creating a Flowchart, Map It! worksheet, markers, colored pencils, or crayons, Engineering Design Process sliders

TEACHER PREPARATION

- If you have new kits, remove all plastic wrap and put batteries in robot mice.

VOCABULARY

- **map** a visual representation (a picture or chart) that shows the position of different parts of something
- **code** a set of instructions written for a computer
- **debug** identify and address problems that prevent a task to be completed
- **robot** a machine that has been programed to perform tasks
- **flow chart** a diagram that represents an algorithm/ process, showing the steps in boxes and their order by connecting them with arrows

LESSON SUMMARY

In this STEM+C lesson, students learn how to read and create a map that communicates where objects belong. Students build on their knowledge about mapping and sequencing from Lesson 1A by exploring the Robot Mouse kit to see how it works. Students learn how to read the provided activity cards that serve as a map of what the mouse's course should look like. Students also must learn to create a flowchart of code, so they can program the mouse through the course maze. Finally, students are challenged to create an original activity card that the toy company can include in their new deck of cards. This lesson prepares students for the engineering design challenge in which they will have to draw a map for Talia to communicate where the organizer and toys should be placed in the toy box. Additionally, students will be exposed to creating a plan, testing, and having to redesign in this activity.

INTRODUCTION

1. **Tie to engineering challenge.** Have students recall what they remember about the toy box organizer challenge.

2. **Introduce the concept.** **Ask:** *What is a map?* **Say:** *Talia wants us to map where the organizer and toys will go. Earlier we read Henry's Map. What did Henry make a map of?* (The farm he lives on - it tells him where everyone belongs.) **Say:** *Today we will learn more about maps. We will help a company make new activity cards for their toy robot mouse.*

3. **Identify where they are in the engineering design process. (Learn)** **Ask:** *What phase are we in on the engineering design process?* (The learn about the problem phase.) **Say:** *We need to continue to learn as much as we can about the problem before we start to plan a solution. Today, we will learn about how to create a map that clearly communicates where objects belong.*

ACTIVITY - Developing an algorithm

4. **Introduce the activity.** **Say:** *The company that makes this Robot Mouse kit needs our help. (Hold up kit.) Their customers want more activity cards to play with. The company would like for each team of students to create an activity card for them to consider including in their new pack of cards.*

5. **Learn about the Robot Mouse kit:** **Say:** *Before we can help make new activity cards for the company, we will have to learn about the toy robot mouse kit. It comes with the following things:* (hold up each item as you say it) *a mouse, coding cards, 16 maze grid pieces, 20 activity cards, cheese, walls, and tunnels. To play with the toy, you must build the course on the activity card, create a flow chart using the coding cards, program the mouse, and then have the mouse run through the course. If the mouse does not reach the cheese, the player must debug the code until it reaches the cheese.*

6. **Build a course.** Have groups locate activity card 20. Using the activity card, have students construct the course. Give students about 10 minutes to build the course. Note: If students are struggling with building with the maze grid pieces, have students who were successful share helpful hints or explain that they should orient all of the pieces in the same direction when building. After 10 minutes, talk about what they learned about the parts of the course and any helpful hints for building with the manipulatives. Explain that walls cannot be moved, and that the mouse must go through each tunnel and complete each action on the course before reaching the cheese.

7. **Learn how the robot works.** **Say:** *First, we will learn about how the mouse*

works. Take out your mouse and put it in the center of you and your teammates. Look, but do not touch the buttons on top of the robot mouse. Each of these buttons tells the mouse a certain command. The yellow circle button clears the mouse's memory. The green circle button makes the mouse go. But remember, it will only go where you have programmed it to go. I want you and your team to take a few minutes to try to figure out what each of the other buttons do. Let everyone have a chance to push one button. After about 3-5 minutes, have students share what they learned about the buttons.

8. **Practice using the coding cards.** Pass out **Robot Mouse: Creating a Flowchart**. Have students locate the coding cards in their kit. Help students connect the images on the cards with the buttons on the mouse. As a class, work together to create a flowchart of the code that can be used to program the mouse to reach the cheese on the course pictured on card 20. Have the students program their mouse and have it run through the course. If there is an error, work as a class to debug the code until the mouse successfully reaches the cheese. Record the code on the **Robot Mouse: Creating a Flowchart paper**. Students should draw simple versions of the images that appear on their coding cards in the boxes to create a flow chart. Students will need to add arrows between the boxes to show in which order the steps should be followed.

9. **Investigate the robot mouse kit.** **Say:** *I am going to give you 20 minutes to learn as much as you can about the robot mouse kit. Complete the three map cards listed on your paper. Remember, you must create the course using the map card, create a flowchart using the coding cards, program the mouse, test the code by letting the mouse run through the course, and copy the flowchart on to your* **Robot Mouse: Creating a Flowchart paper**. At the end of the 20 minutes, have students share what they learned. Note: Allow students to select one of the following roles on the team: course builder, coder, programmer, and recorder. Have students rotate jobs for each new card they try.

10. **Revisit the problem.** **Ask:** *What does the company who makes the robot mouse kit need our help with? What other information do you need to know before you begin to create your map?*

11. **Solve the problem.** Give students 20 minutes to physically build a course and then draw it on the **Map It! worksheet**. At about 10 minutes they should be drawing their map. If time permits, allow teams to check each others' work.
    - Option 1: Have teams switch spaces with another team. Teams should ensure that the maps match the physical model. Have students come together and share feedback.
    - Option 2: Have students take pictures of their physical courses and then take them apart. Have teams switch maps and construct the course. Compare the photo to the newly constructed course to see if it matches. Provide feedback.

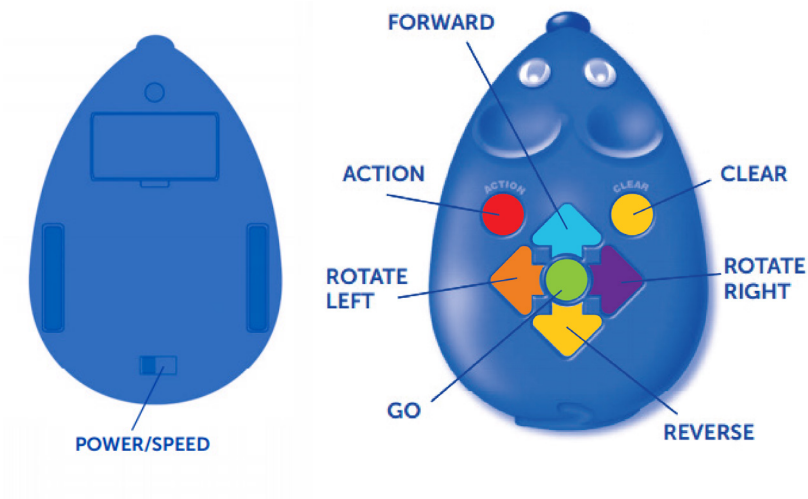
CLOSURE

12. **Tie back to the engineering challenge.** **Ask:** *What are some things to remember when creating a map? Think about toy box organizer challenge. What similarities do these two challenges have? What differences?*

TEACHER NOTES

Code & Go™ Robot Mouse Activity Set

Activity Guide



Manually rolling the wheels may damage the motor.

Pieces Included:

- 14 FORWARD step coding cards
- 4 BACKWARD, ROTATE RIGHT, ROTATE LEFT, and ACTION step coding cards
- 22 Maze walls
- 16 Maze grid pieces that connect to form a large board
- 10 Double-sided Activity Cards
- 3 Tunnels
- 1 Robot mouse (Colby)
- 1 Cheese wedge
- 20 Activity cards

Basic Operation

POWER Slide to turn the power ON

SPEED Choose between Normal and Hyper. Normal is best for regular use on the maze board, while Hyper is best for play on the ground or other surfaces.

FORWARD For each FORWARD step, Colby moves forward a set amount (5") (12.5 cm).

REVERSE For each REVERSE step, Colby moves backward a set amount (5") (12.5 cm).

ROTATE RIGHT For each ROTATE RIGHT step, Colby will rotate to the right 90 degrees.

ROTATE LEFT For each ROTATE LEFT step, Colby will rotate to the left 90 degrees.

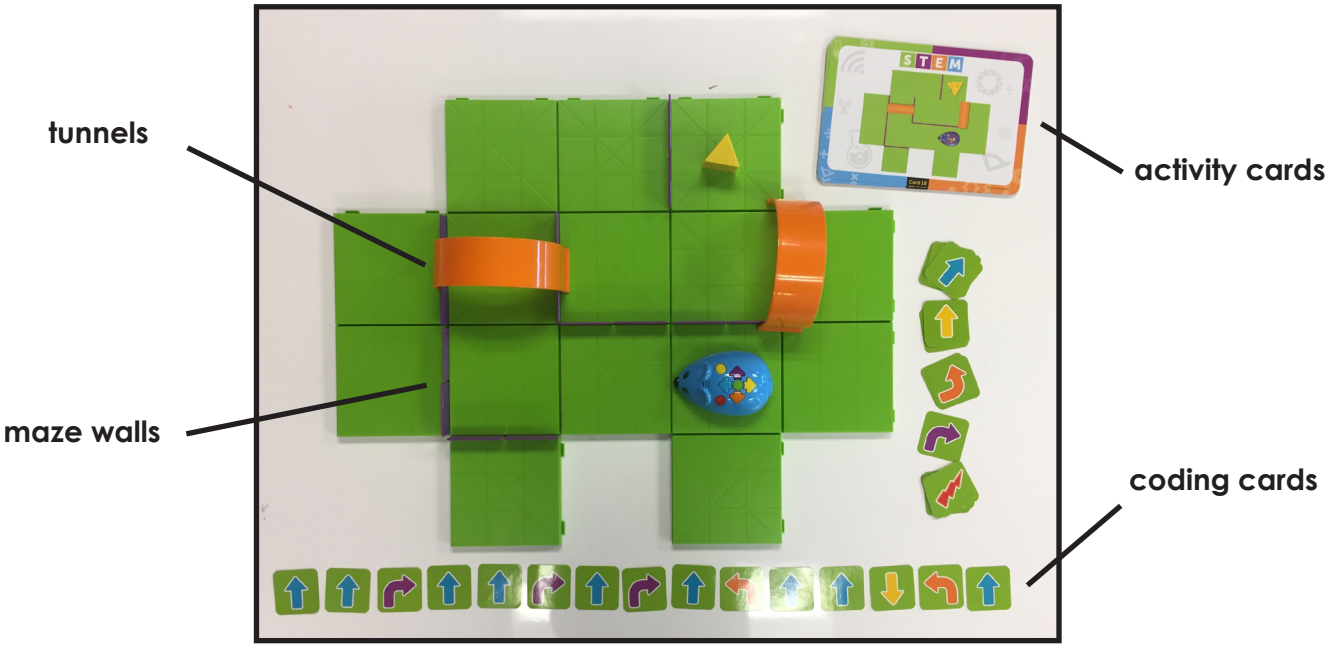
GO Press to execute or perform your programmed sequence.

CLEAR To clear all programmed steps, press and hold until you hear a confirmation tone.

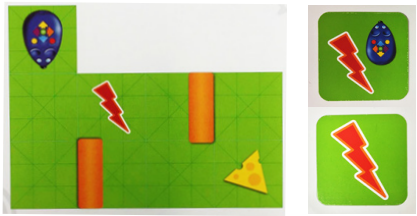
ACTION For each ACTION step, Colby will perform one of 3 RANDOM actions:
- Move forward and back
- Loud "squeak"
- "Chirp-chirp-chirp" and light up eyes

Original mouse image and text are from https://www.learningresources.com/text/pdf/LER2831_guide.pdf

Example Solution for Activity Card



Example of ACTION step on activity card and coding cards:



Using Maze Walls and Tunnels

Create a maze by inserting the walls into the lines on the board. For mazes with tunnels, be sure to have Colby pass under each tunnel before reaching the cheese. The tunnel rests on the board - not in the grooves. Follow the patterns on the activity cards to re-create each maze. Then, program Colby to maneuver through the maze and to the cheese! Because the maze is customizable, children can build their own maze, try their hand at programming Colby from start to finish, or invite a friend to try the maze they created.

Hint: Orient all maze grid pieces in the same direction when building the board.

Coding Cards

Colorful coding cards help children keep track of each step in a sequence. Each card features a direction or "step" to program into Colby. Cards are color-coordinated to match the buttons on the mouse.

For the ease of use, we recommend lining up each card, in sequence, to mirror each step in a program.

Activity Cards

This set also includes 10 double-sided Activity Cards featuring 20 mazes. These cards can be used as an educational tool to help young programmers "ramp up" their skills. Start out with card 1 to teach the very basics, and follow in number sequence as logic and critical thinking skills improve.

For all the mazes on the activity cards, the goal is to program your robot mouse to reach the cheese. Each of these mazes should be completed in the fewest steps possible.

Lesson 1B

Name_____

Robot Mouse - Creating a Flowchart

Directions: Build the course. Create a flowchart. Program the robot mouse. Record your code.

1. activity card 20

2. activity card 3

Lesson 1B

Name_____

Robot Mouse - Creating a Flowchart

Directions: Build the course. Create a flowchart. Program the robot mouse. Record your code.

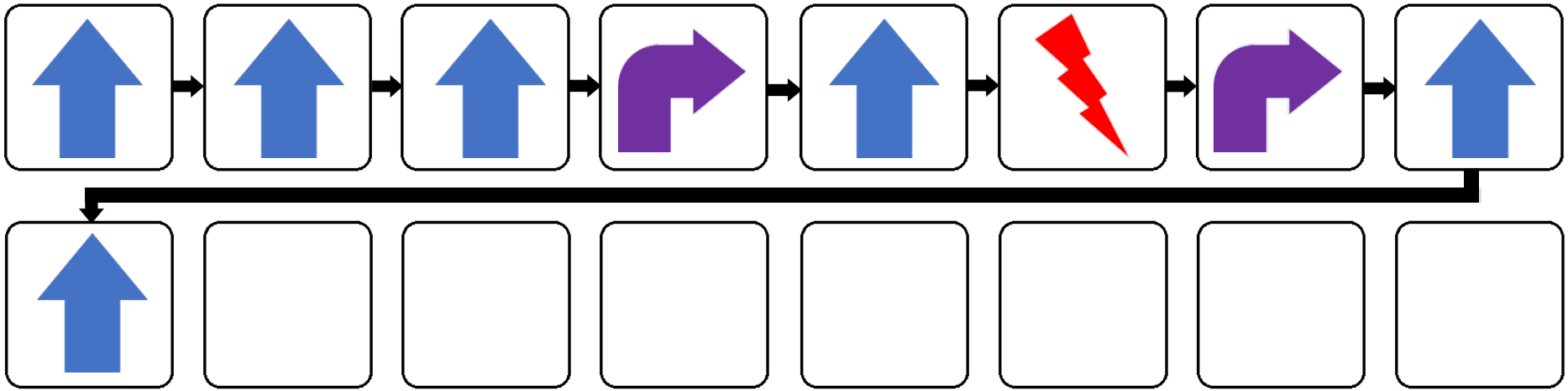
3. activity card 5

4. activity card 18

Lesson 1B Robot Mouse - Creating a Flowchart

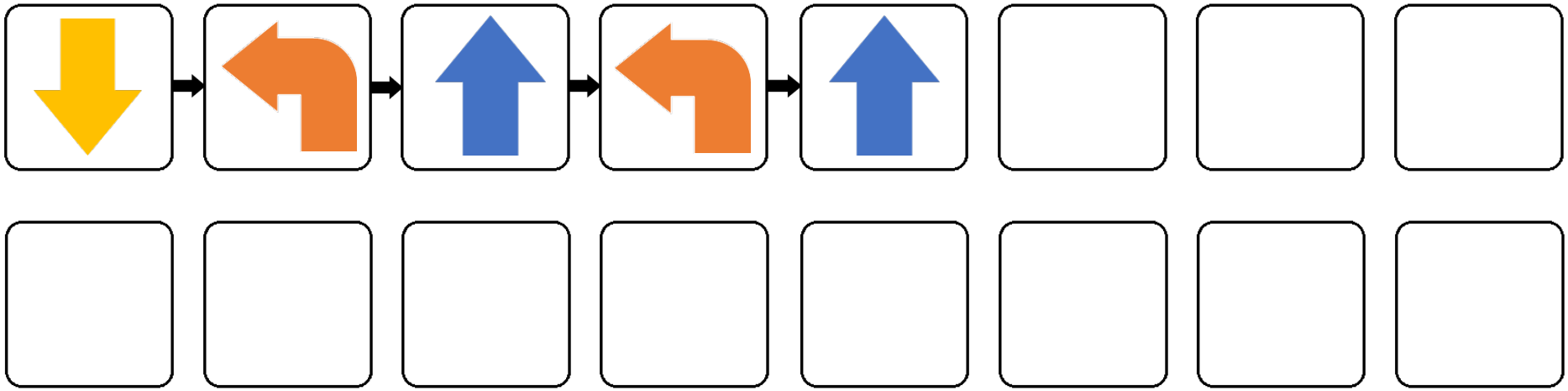
Directions: Build the course. Create a flowchart. Program the robot mouse. Record your code.
NOTE: There are multiple correct solutions to each card - not all possible solutions are provided.

1. activity card 20



Other possible solution(s): F, F, RR, F, RL, F, A, RL, F, RL, F, RL, F, RR, F; F, F, RR, F, RL, F, A, RL, F, RL, F, B, A, RL, F, F

2. activity card 3

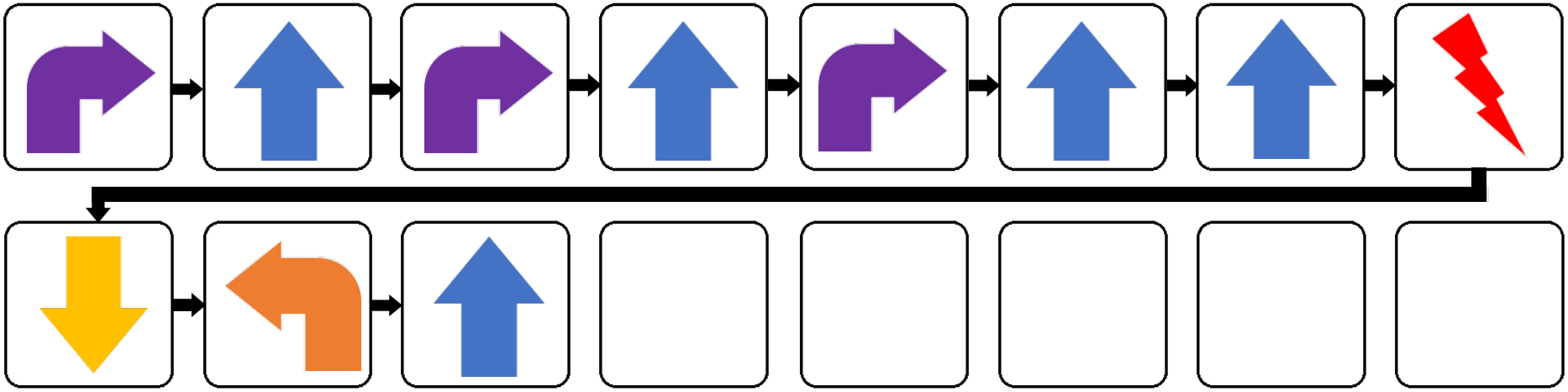


Other possible solution(s): RL, F, RL, F, F; RR, RR, F, RR, F, RL, F

Lesson 1B Robot Mouse - Creating a Flowchart

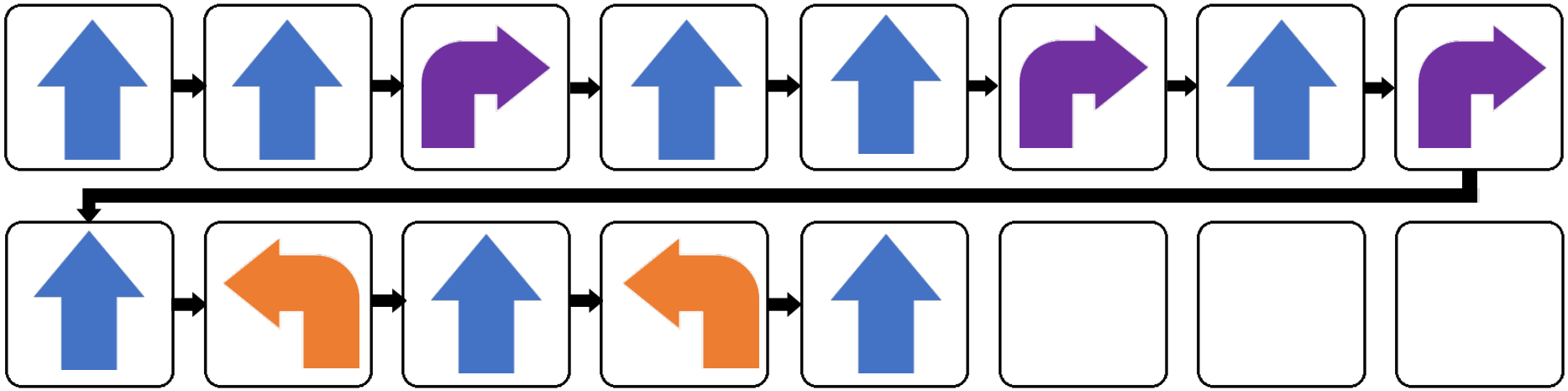
Directions: Build the course. Create a flowchart. Program the robot mouse. Record your code.
NOTE: There are multiple correct solutions to each card - not all possible solutions are provided.

3. activity card 5



Other possible solution(s): RR, F, RR, F, RR, F, F, A, RL, RL, F, RR, F; RL, B, RL, F, RR, F, F, A, B, RL, F

4. activity card 18



Other possible solution(s): B, RR, F, RL, F, F, RR, F, RL, F, RL, F, B, RL, F, RR, F, RL, F, RL, F

Lesson 1B

Name_____

Robot Mouse - Creating a Flowchart

Directions: Build the course. Create a flowchart. Program the robot mouse. Record your code.

1. activity card ____

2. activity card ____

Lesson 1B

Name_____

Robot Mouse - Creating a Flowchart

Directions: Build the course. Create a flowchart. Program the robot mouse. Record your code.

3. activity card ____

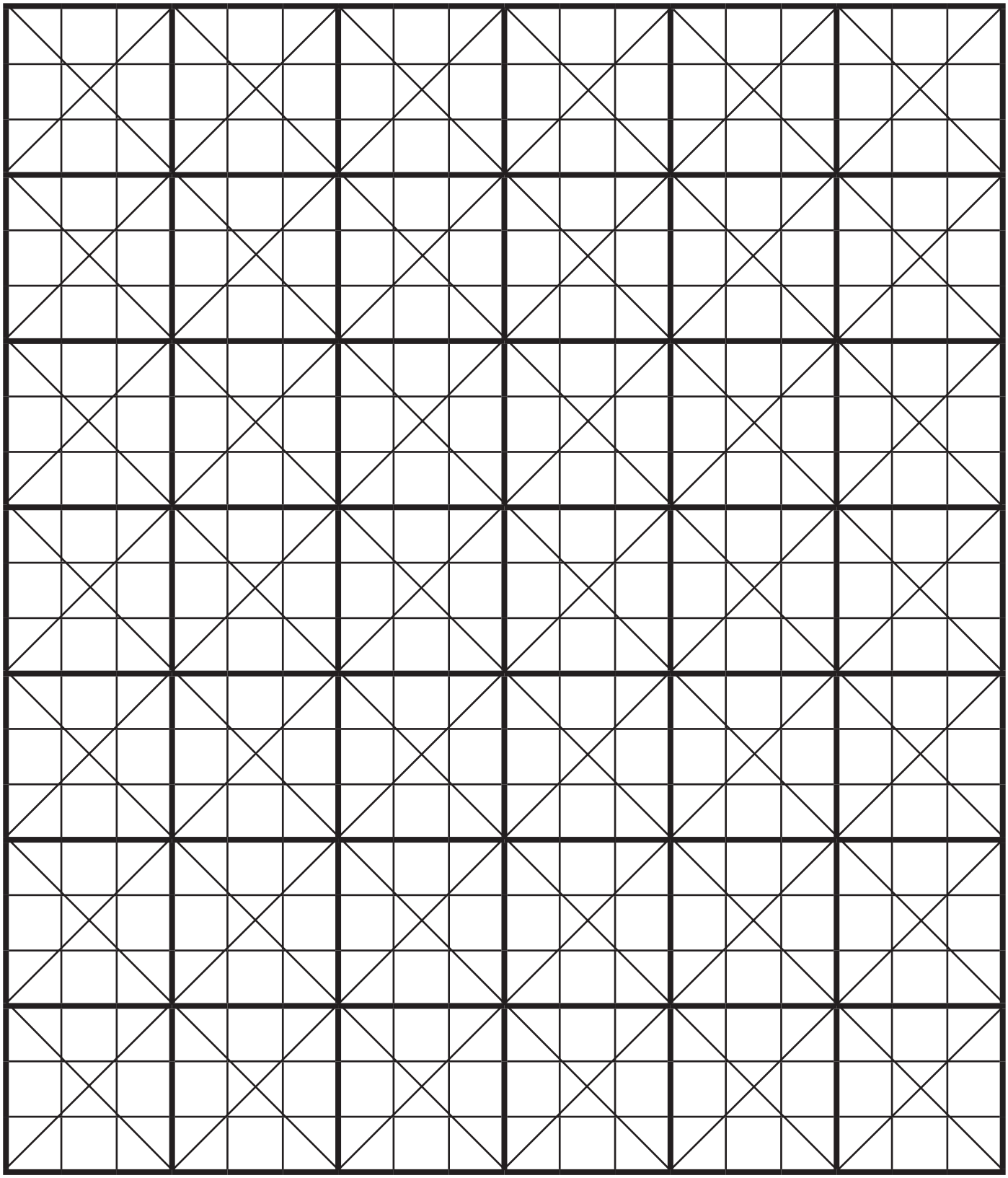
4. activity card ____

Lesson 1B

Name_____

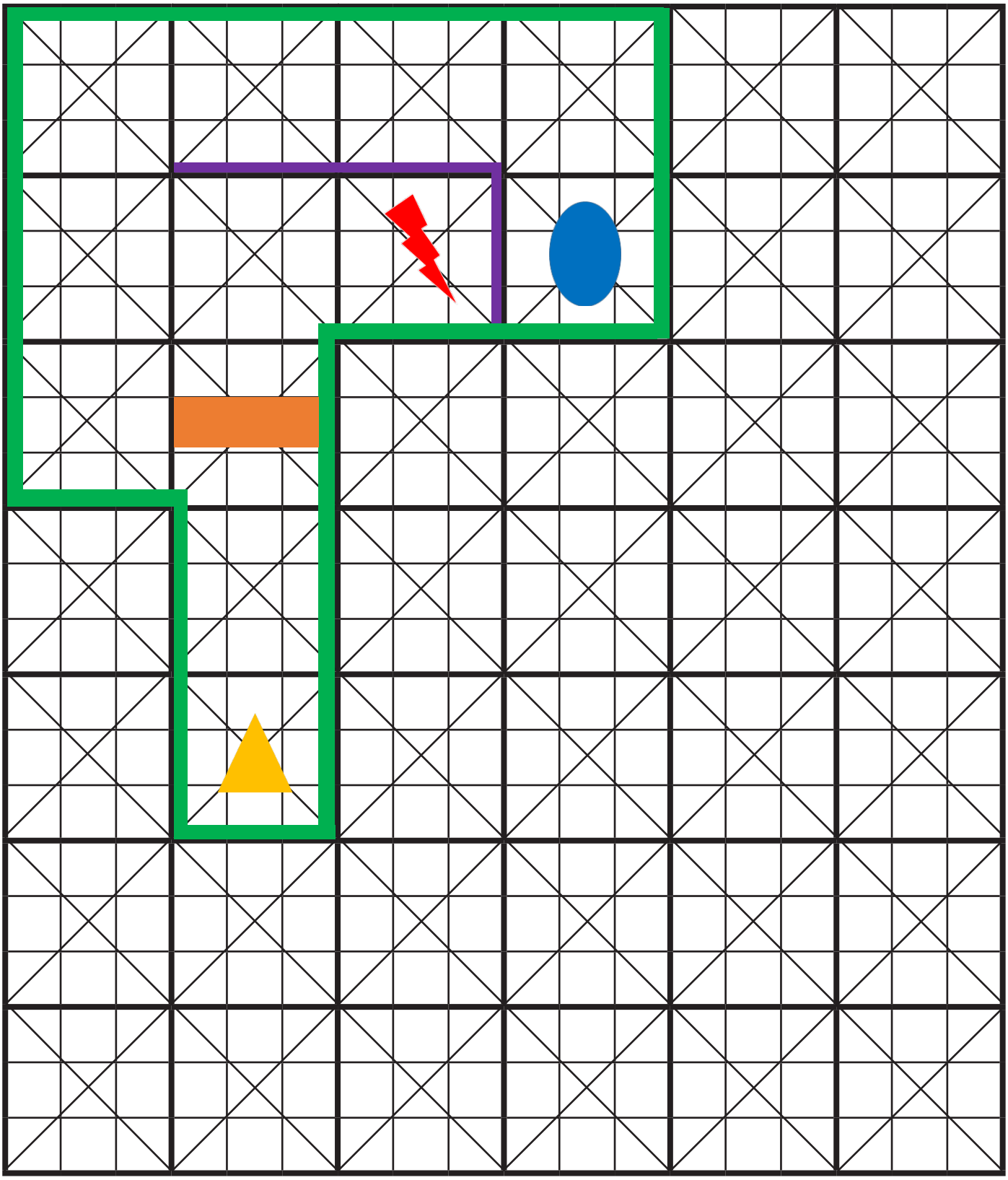
Map It!

Directions: Record your new activity card below. Trace the outline of the course in green. Use the following to represent the course pieces: blue oval = mouse, purple line = wall, orange rectangle = tunnel, yellow triangle = cheese, and red lightening bolt = action.



Lesson 1B Map It!

Directions: Record your new mouse course below by tracing the outline of the course in green. Use the following colors to represent the other course pieces: blue = mouse, purple = wall, orange = tunnel, yellow = cheese, and red = action.



Lesson 2A

Treasure Hunt

FOCUS/KEY CONCEPTS
Students will be able to:
- **Mathematics:** recognize that standard units are necessary to translate distances to others.

STANDARDS
National
- CCSS-MC: 2.MD.A.1

MATERIALS
- **Per student:** Treasure Hunt - Help Find a Solution worksheet, Engineering Design Process sliders
- **Per class:** Character Name Tags, Map Location Markers, Susie's Path map, Brother's Path map, Dad's Path map, All Paths map

TEACHER PREPARATION
- Prepare a large copy of the Treasure Hunt Educator Resources
- Prepare character cards (front and back) for Susie, brother, and father. Print out, cut out, laminate, punch hole, and add and knot string to make name tags that can be worn around the neck.
- Print and hang up location signs around the room.

VOCABULARY
- **unit** An amount used again and again to measure something

LESSON SUMMARY

In this STEM+C lesson, students are introduced to the concept of standard and nonstandard units. Students learn that there is a need for a common unit. In this lesson, they explore this idea through a modeling activity, in which the students need to help Susie create a treasure map that can be followed by anyone regardless of their stride. After the problem is acted out for them, students work in pairs to come up with a solution for Susie. This lesson will help begin building mathematical background knowledge about measurement that students will use to communicate information about their prototype to their client.

INTRODUCTION

Note: Prior to the start of the lesson, hang up the **Map Location Markers**.

1. **Tie to engineering challenge.** Remind students of the toy box organizer challenge. **Ask:** *Who can tell me why we're helping Talia? What problem are we helping her solve?*

2. **Introduce the lesson.** **Say:** *Before we can make our designs, we need to learn a little more about the mathematics that we are going to need to help make our toy box organizers. In this lesson, we are going to help Susie with a problem she is having. By helping Susie, we are also going to help ourselves learn some things we need to know to design our toy box organizers.*

3. **Identify where they are in the engineering design process. (Learn)** **Ask:** *Where do you think we are in the engineering design process? Where should we move our paper clip and why should we move it there?* Remind students that an important part of the engineering design process is learning about the problem and ways to solve the problem.

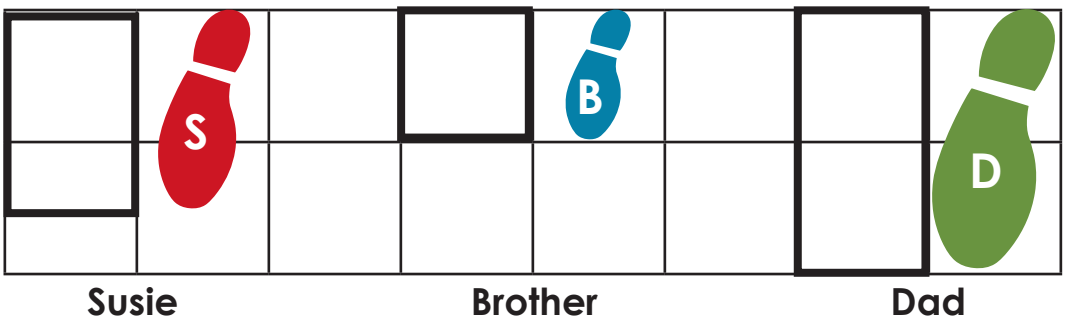
ACTIVITY - Modeling activity

Note: This part of the activity needs open space. If you are unable to move your desks to allow for students to act out the problem, consider moving into an open space in your school, such as the cafeteria, gym, library, or playground/blacktop.

4. **Context setup.** Find three volunteers from the class to help act out the problem. Assign each student a role: Susie, Brother, and Father. Have them put on the **Character Name Tags**. Quietly inform them of the size step their character needs to take: normal (Susie), little (Brother), and big (Father). Point out to them where the **Map Location Markers** are around the room.

5. **Treasure Hunt Problem.** Introduce the class to the problem by having three students role play the scenario as you read **The Treasure Hunt Problem** aloud to the class. After watching the problem scenario, **ask:** *What is Susie's problem?* (She wants her friends to go on a treasure hunt, but doesn't know where to bury the treasure and what directions to give them.)

Treasure Hunt



6. **Solve the problem.** Select one of the versions of the four **path maps.** Note: The first version of the Treasure Hunt maps does not have a grid on it and is, therefore, more suitable for younger students. Use the maps to answer any questions students may have. Put students into pairs and have them work together to figure out a way to help Susie. Tell students that there are many different possible answers to this problem.

CLOSURE

7. **Sharing Solutions.** After the pairs have had time to talk and find at least one solution together, have them share their ideas for how to help Susie. This helps students get at the idea that there can be many different ways to solve problems and that there is no correct/best answer. Note: The goal of this activity is to have students understand that an agreed upon measuring tool is needed. It can be anything that has a set length that does not change. If students are struggling with this idea, stop the lesson at this point and let them know that you will come back to this problem after reading the book *How Big is a Foot?*

8. **Tie back to engineering challenge.** Connect what students learned to the engineering challenge. **Say:** *At the beginning of this lesson we said that we were going to learn something that we can use to help us solve the toy box organizer problem. What did you learn from solving Susie's problem that might be helpful when designing our toy box organizers?*

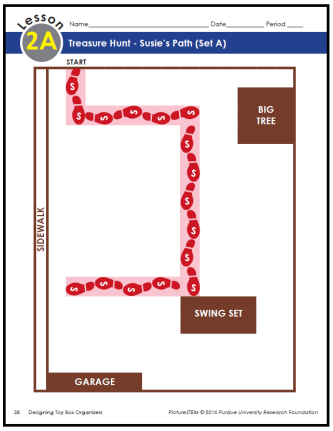
TEACHER NOTES

Lesson 2A The Treasure Hunt Problem

Say: *Susie wants to make a treasure hunt for her upcoming birthday party.*

Have the child playing Susie act out the following directions. **Say:** *She decided that her trail would take two steps toward the garage, four steps toward the big tree, six steps toward the swing set, and four steps to the sidewalk.* Have Susie remain where she lands.

Show a large copy of Susie's Path (Versions 1 or 2). **Say:** *Here is a map of her trail.*

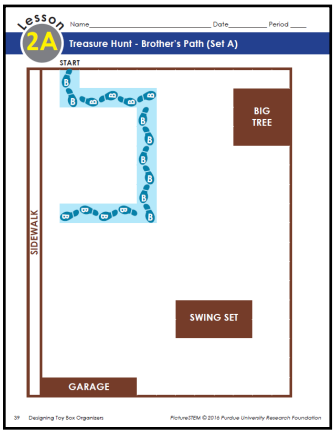


Say: *When she finished walking those directions, she placed her treasure box on the location where she was going to bury it and went to get her younger brother to have him try to follow her map.*

Have the child playing Brother act out the following directions. **Say:** *Brother took two steps toward the garage, four steps toward the big tree, six steps toward the swing set, and four steps to the sidewalk.* Have Brother remain where he lands.

Say: *But when her younger brother started in the same place and followed the same directions, he ended up in a different place!*

Show a large copy of Brother's Path (Versions 1 or 2). **Say:** *Here is a map of his trail.*

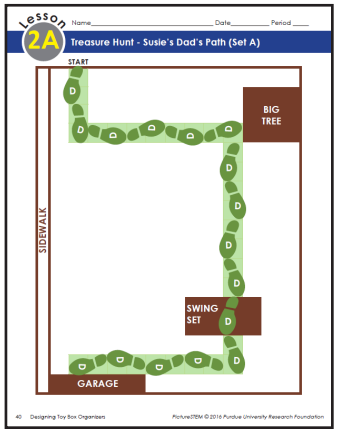


Lesson 2A The Treasure Hunt Problem

Say: *Now, Susie isn't sure where to bury her treasure and so she asked her dad to help.*

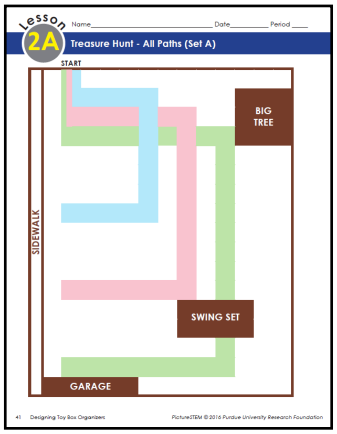
Have the child playing Dad act out the following directions. **Say:** *Dad took two steps toward the garage, four steps toward the big tree, six steps toward the swing set, and four steps to the sidewalk.* Have Dad remain where he lands.

Show a large copy of Dad's Path (Versions 1 or 2). **Say:** *Here is a map of his trail.*



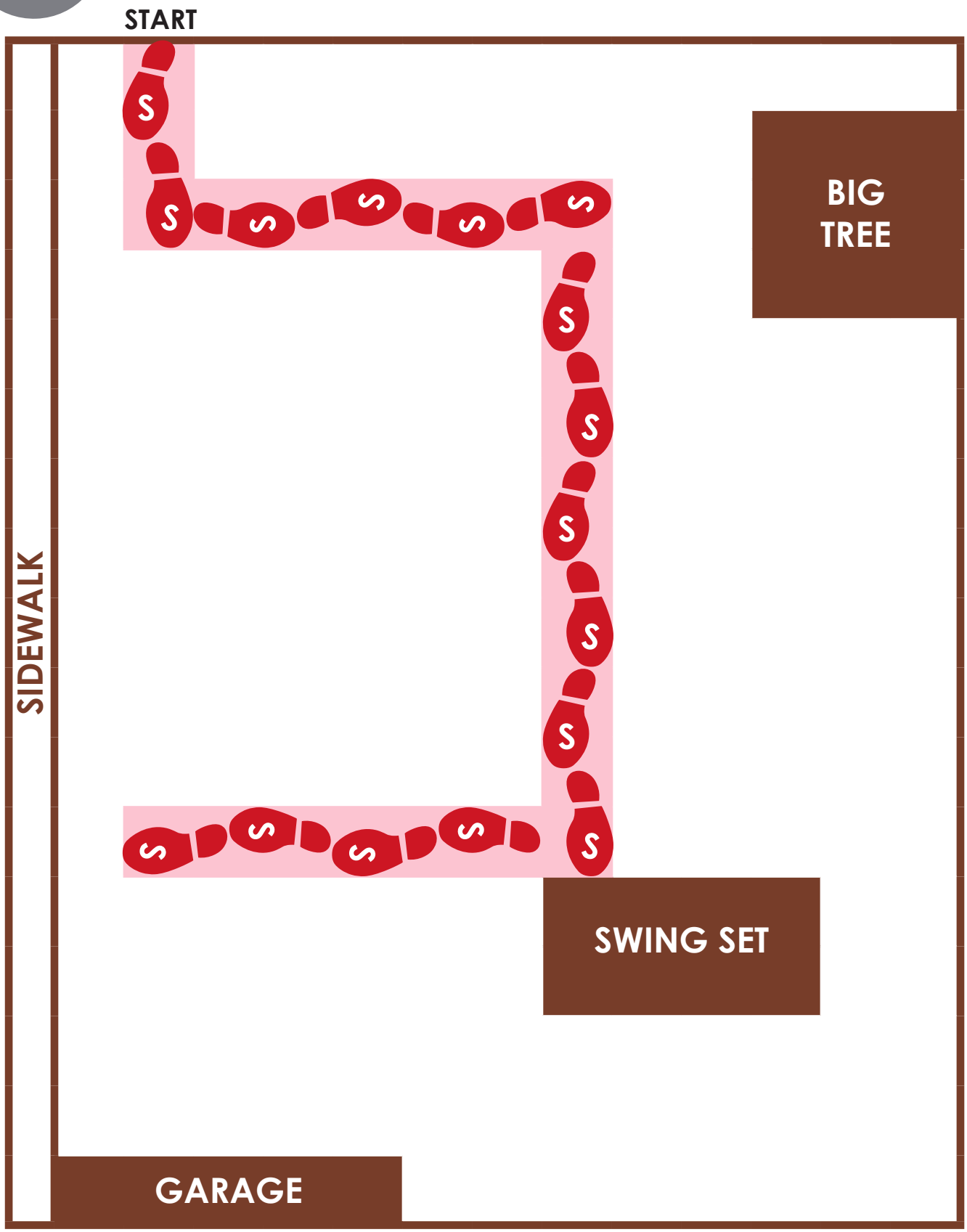
Say: *He started at the same place, but ended up in a place different from Susie and her brother!*

Show a large copy of all tree of their paths (Versions 1 or 2). **Say:** *Here is a map of all three of their paths.*

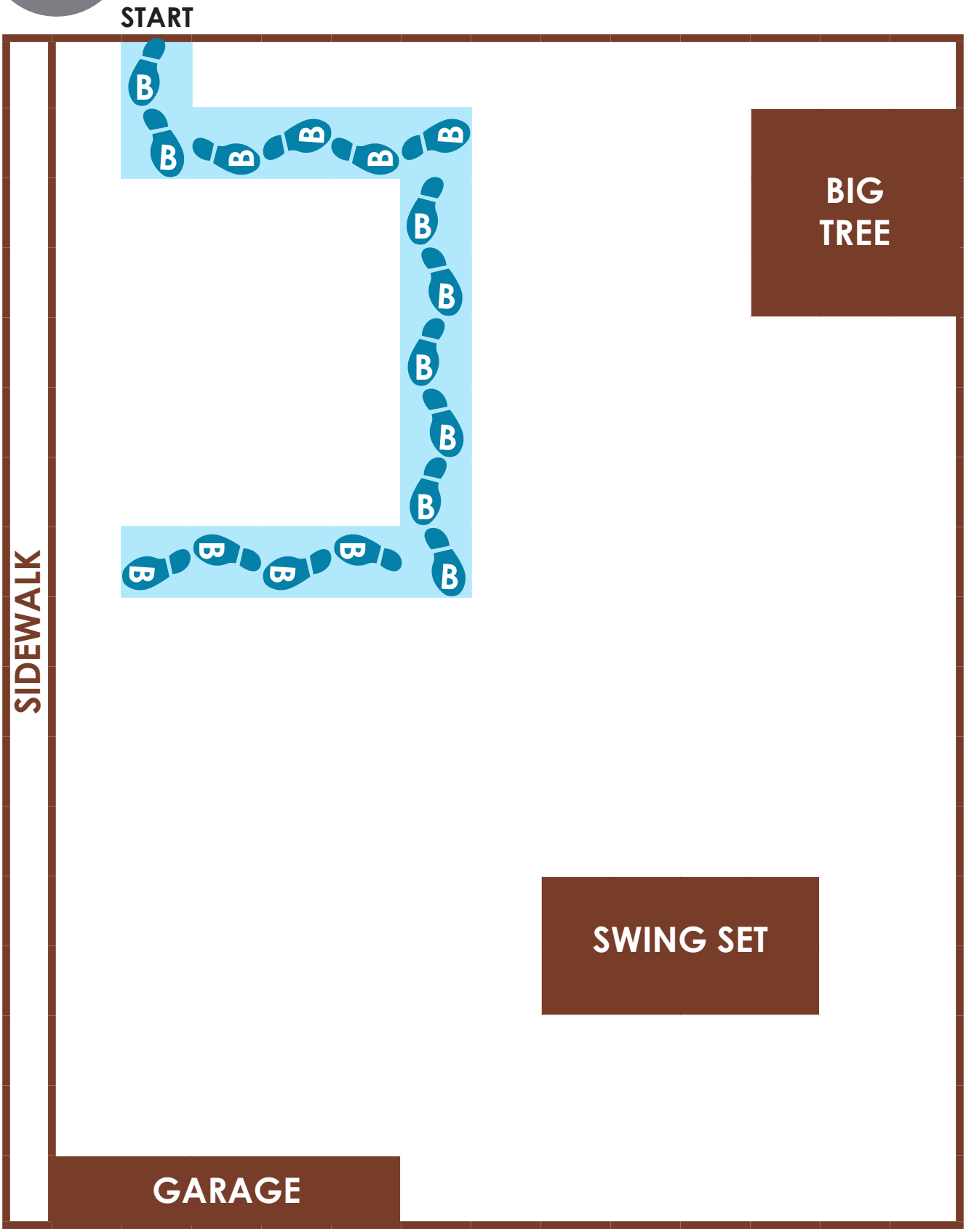


Say: *Now Susie is really confused! She really wants to have her friends go on a treasure hunt for her party, but she isn't sure what to do and where to bury the treasure. She wants it to be a little bit difficult, but she also wants everyone at the party to find the treasure. Can you help her?*

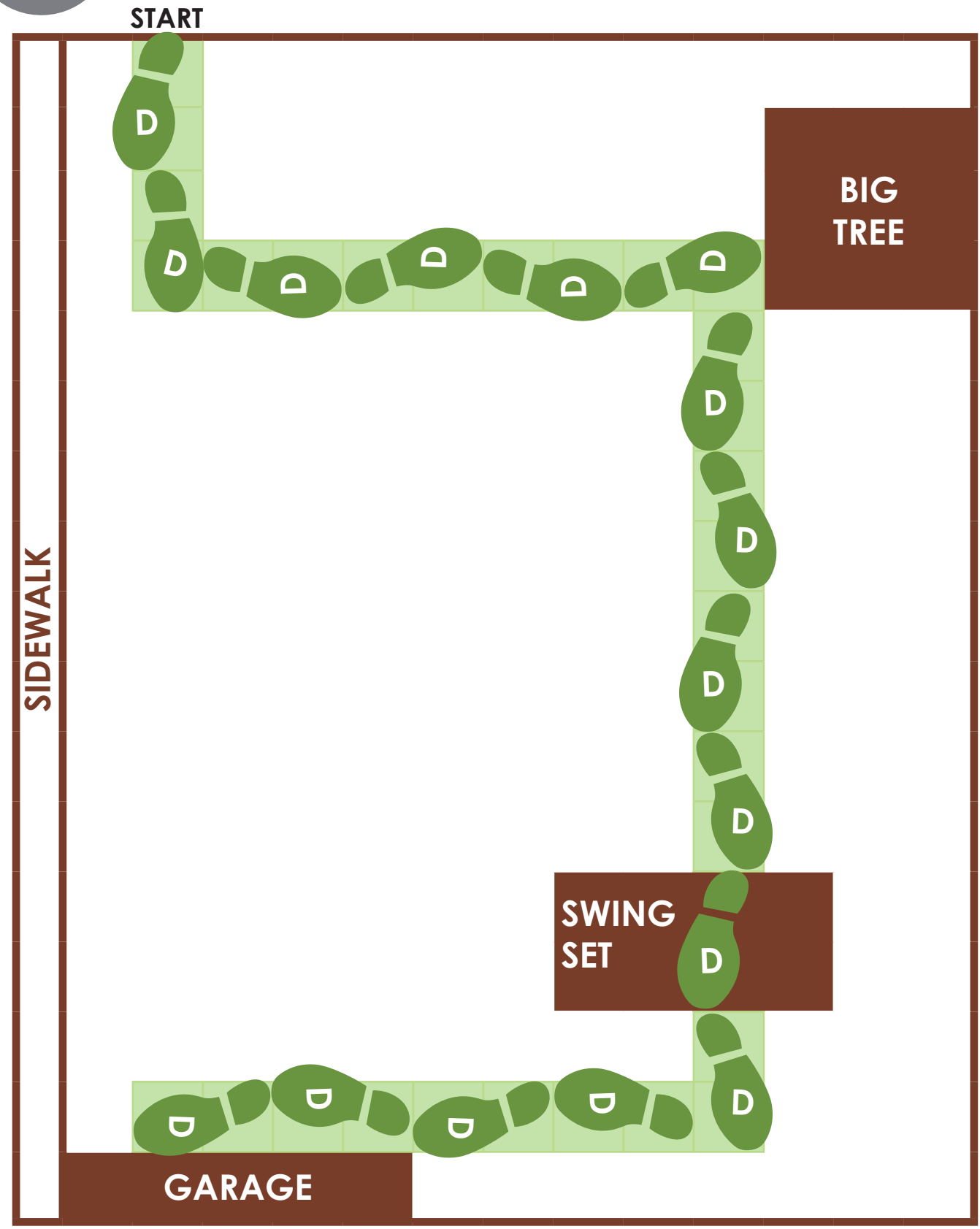
Lesson 2A Susie's Path (Version 1)



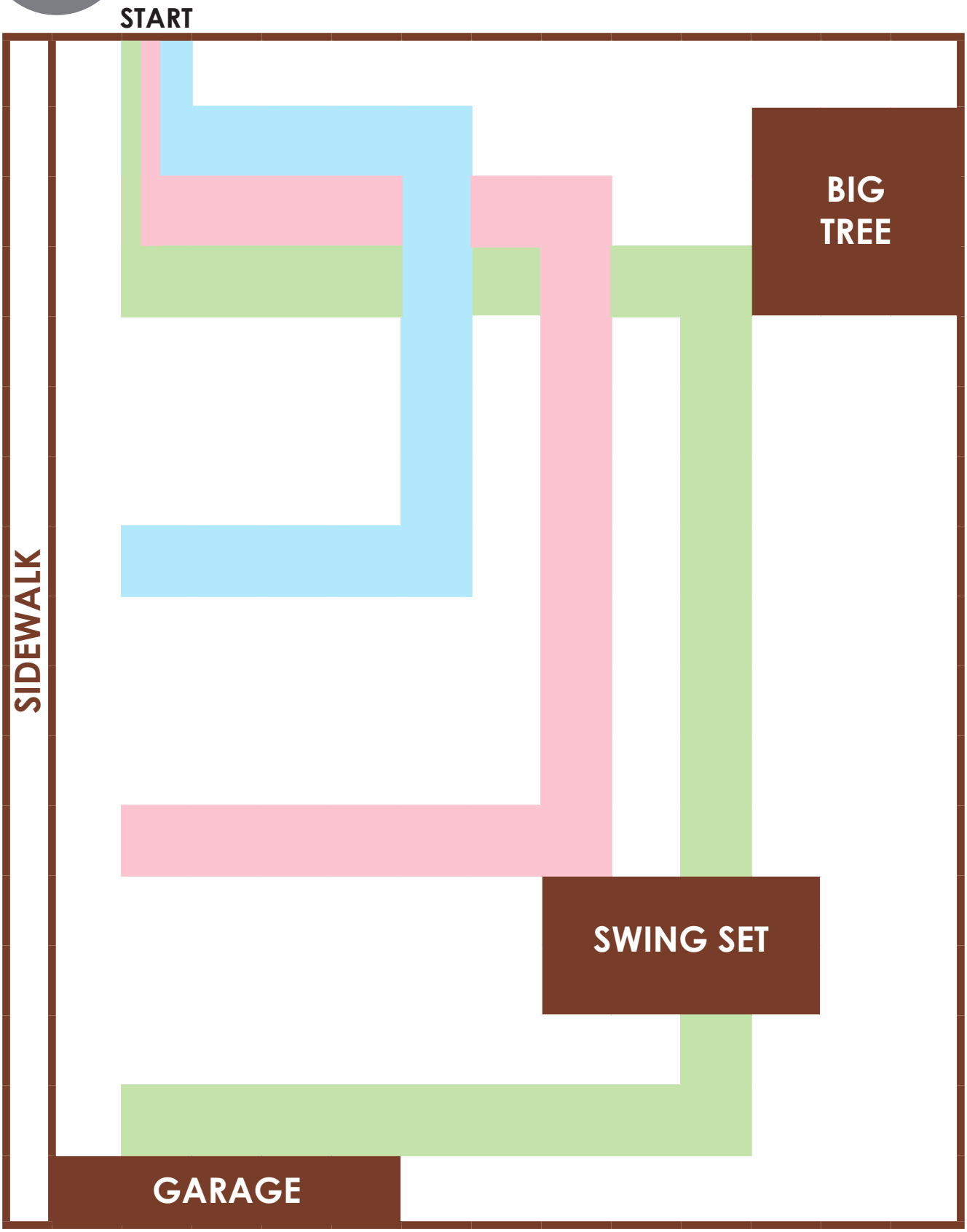
Lesson 2A Brother's Path (Version 1)



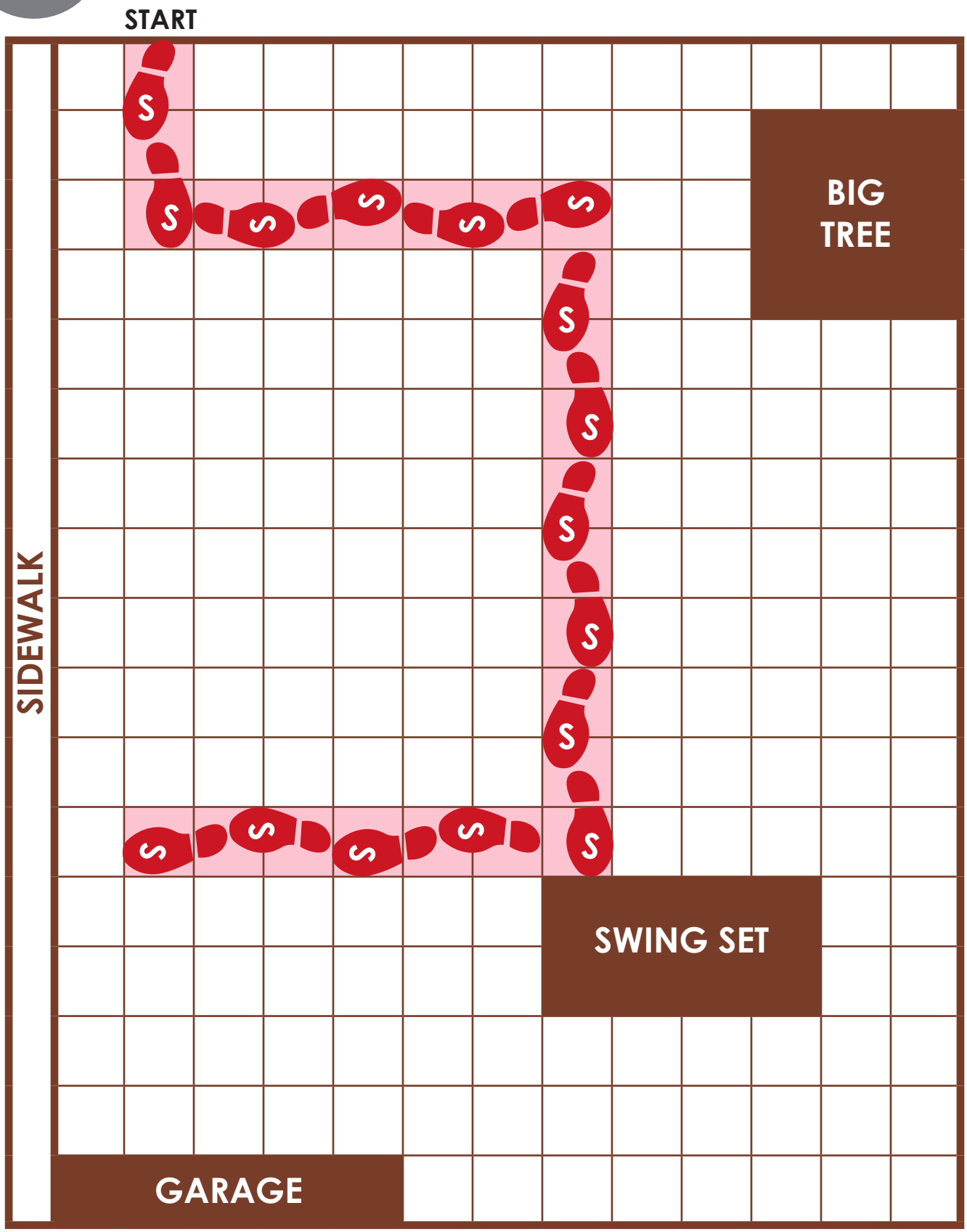
Lesson 2A Susie's Dad's Path (Version 1)



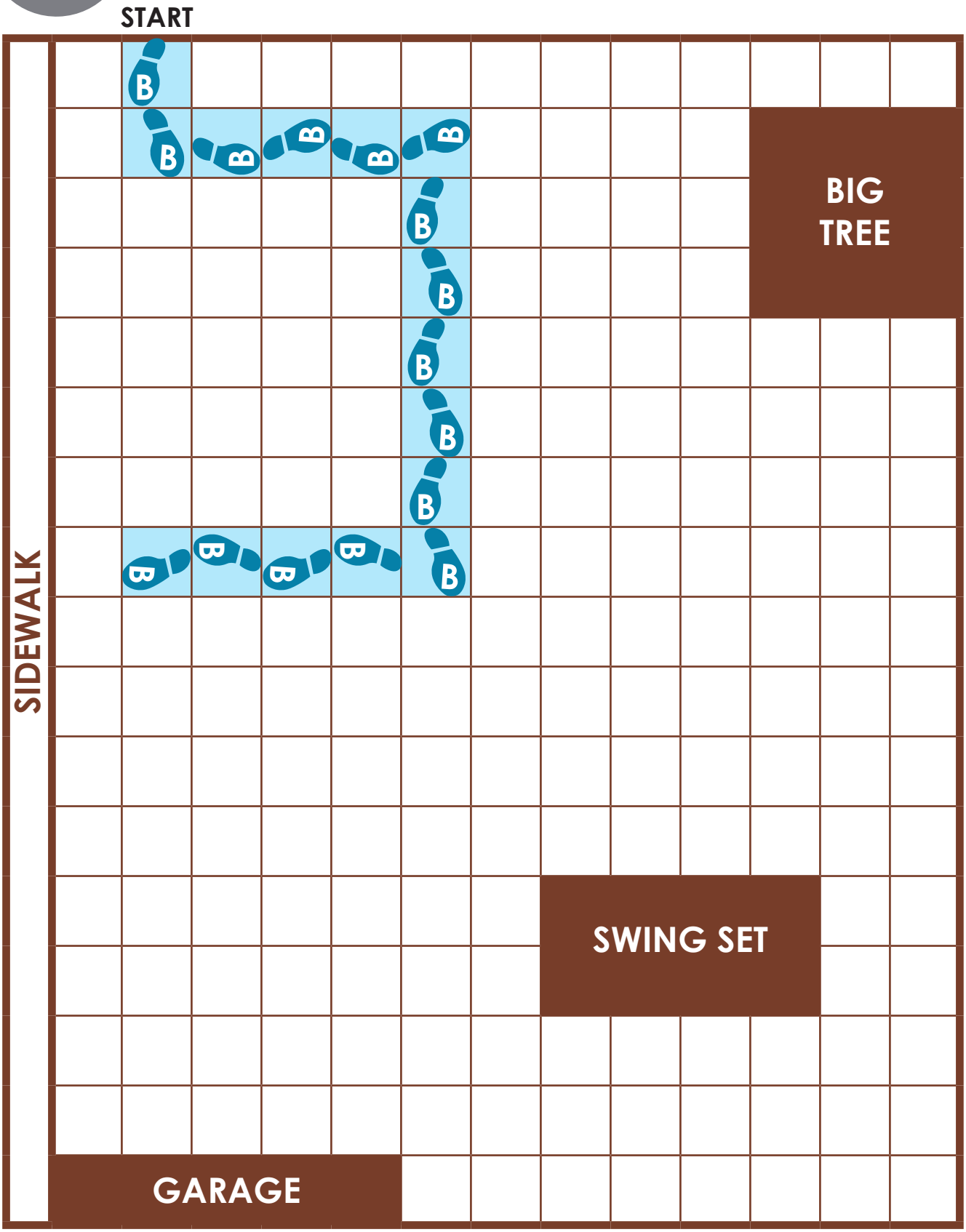
Lesson 2A All Paths (Version 1)



Lesson 2A Susie's Path (Version 2)

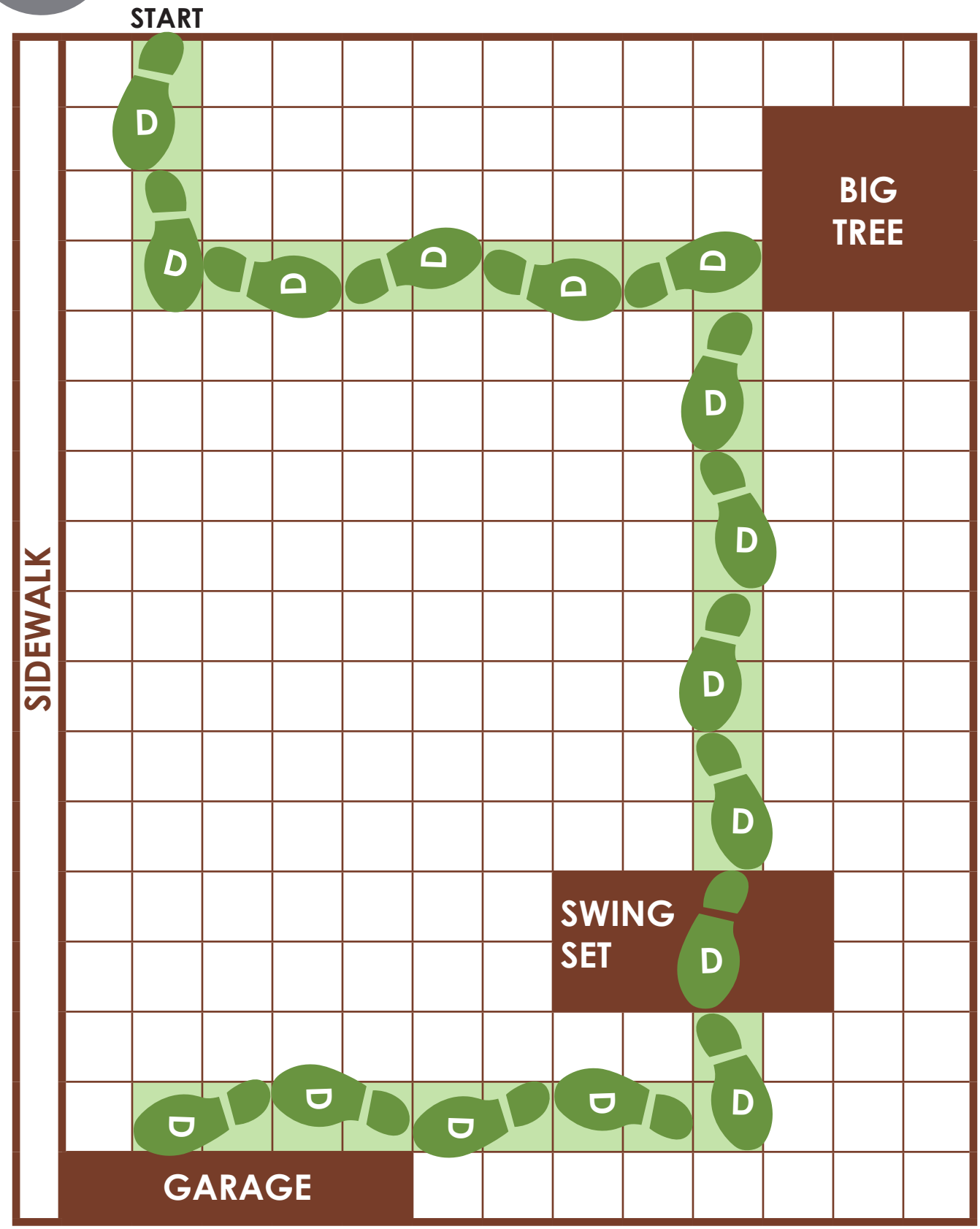


Lesson 2A Brother's Path (Version 2)

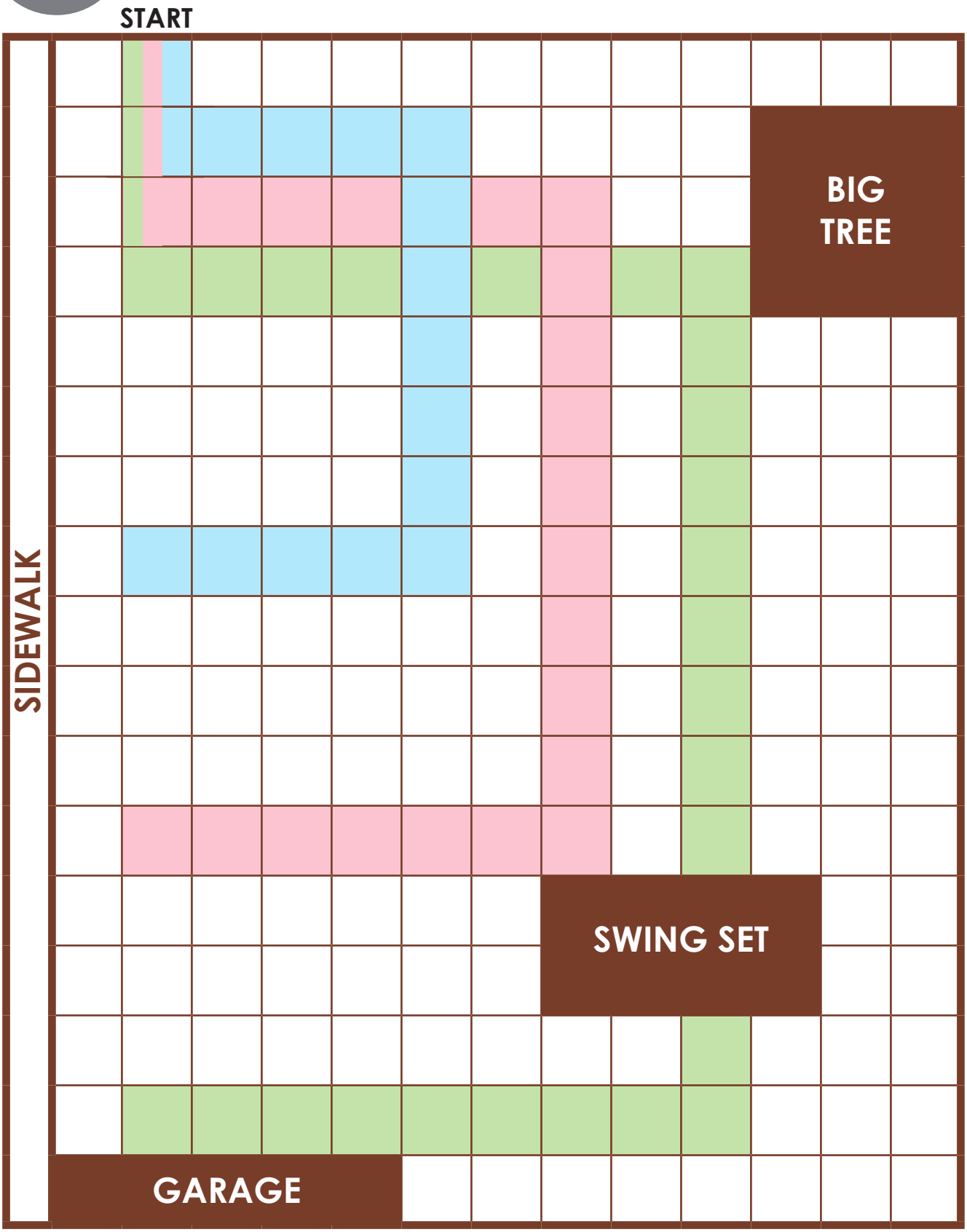


Lesson 2A

Susie's Dad's Path (Version 2)



Lesson 2A All Paths (Version 2)



Character Name Tags (Susie & Brother)

Susie

Brother

Lesson 2A

Character Name Tags (Dad)

Dad

big

tree

swing

set

garage

sipdewalk

Lesson 2A

Name_____

Treasure Hunt - Help Find a Solution

Directions: Write an explanation or draw a picture for what you would tell Susie to do to help her friends find her treasure.

Lesson 2B

How Big is a Foot?

FOCUS/KEY CONCEPTS

Students will be able to:

- **Literacy:** identify key ideas and details in the story by asking and answering questions such as "who," "what," "when," "where," "why" and "how."
- **Mathematics:** identify why it is important to use standard units of measurement when building an object.

STANDARDS

National

- CCSS-ELA: RL.2.1
- CCSS-MC: MD.A.2

MATERIALS

- **Per student:** Story Structure graphic organizer, Engineering Design Process sliders
- **Per class:** *How Big is a Foot?* by Rolf Myller

TEACHER PREPARATION

- Prepare a large copy of story structure sheet (on chart paper, whiteboard, SMART board, etc.)

VOCABULARY

- **carpenter** A person who builds objects out of wood
- **apprentice** A person who is learning a skill from another person

LESSON SUMMARY

This literacy lesson reinforces the idea about the need for a standard unit of measurement that the students explored in the previous lesson with Susie's treasure hunt. The book *How Big is a Foot?* by Rolf Myller tells the story of a king who uses a non-standard measurement (his foot) to order a bed for his wife, the queen. Unfortunately, the bed makers' foot has a different size, and so he ends up with the wrong-size bed for the queen. This story introduces students to the idea that foot size varies between people, and, therefore, feet are not good units of measurement, while working on identifying important ideas and details in the story. Students will use this mathematical knowledge when communicating their design solutions to their client. Reading strategy: using story structure to identify key details.

INTRODUCTION

1. **Tie to engineering challenge.** **Ask:** *What problem are we trying to solve for Talia's Toy Box Company?* (Their travel toy box gets too messy; they need us to design a toy box organizer that will help keep the toys organized and easy to grab.)

2. **Identify where they are in the engineering design process. (Learn)** **Ask:** *Where do you think we are in the engineering design process?* (point to the Engineering Design Process chart) *Where should we move our paper clip and why should we move it there?* **Say:** *Before we can help the toy company create a better toy box, we need to learn a little bit more about measurement. This will help us give the toy box company detailed instructions on how to build our toy box organizers and to communicate exactly how much material they will need to build them.*

ACTIVITY - Using story structure to identify key details

3. **Introduce the book.** Have students gather on the floor. Introduce the book, *How Big is a Foot?* by Rolf Myller.

4. **Introduce/Explain the reading strategy and why it is useful.** Tell students that they will be working on some strategies that they can use to understand what is happening in the story. They will answer some key questions that include the following words: who, when, what, why and how.

5. **Model the comprehension strategy – story structure.** During this lesson, students will be listening to the story, while the teacher reads the story aloud, and then they will practice using the strategy. Before reading the story aloud, explain that stories have a structure, which helps the reader understand what is going on. By identifying different parts of this story students will be able to better understand it. **Say:** *We will be using question words to help us identify important parts of the story. For example, we can ask, "Who are the main characters of this story?"*

6. **Read the story aloud.** While reading, use the following to guide the lesson development process:
   - Teach new vocabulary at the point of contact.
   - Target comprehension skill: answering questions about "who," "what," "when," "where," "why," and "how."
     - **WHO** are the main characters?
     - **WHEN** did this story take place?
     - **WHAT** was the king's first problem? **WHAT** happened in the story? **WHAT** was the apprentice's problem?
     - **WHY** was the king unhappy? **WHY** was the first bed the wrong size?
     - **HOW** did the apprentice solve the problem?

- Encourage higher-level thinking and monitor comrehension by pausing for "teacher think alouds" and asking questions about the text.

CLOSURE

7. **Whole group practice/review.** Pass out the **Story Structure graphic organizer**. Have students answer the questions by either drawing or writing a response. Although there are several correct answers to some of the questions, steer the main discussion to focus on the mathematics represented in the story.

   Example responses:

WHO are the main characters?	King, Queen, Apprentice
WHEN did this story take place?	A long time ago, before beds were invented.
WHAT was the problem?	The first bed was too small for the queen.
WHY was there a problem?	The King's feet were bigger than the apprentice's feet.
HOW did they solve the problem?	They made an exact copy of the King's foot to be used as a common measurement.

8. **Summarize.** Show students how they can use the information from their organizer to help retell what happened in the story. Example: the main characters in this story were the king, queen, and the apprentice (who). The king wanted to surprise the queen with a present for her birthday, so he decided to give her a bed, but didn't know what to tell the apprentice in terms of the size of the bed, so he measured with his feet (what). However, the bed was too small for the queen, and the king was unhappy, so he threw the apprentice in jail (why). The apprentice realized that his feet were smaller than the king's feet, and so he asked for a marble copy of the king's foot and was able to build a bed that fit the queen (how).

9. **Connect back to Treasure Hunt.** If students have not made the connection on their own, ask them about how the king's problem was similar to Susie's problem.

10. **Tie back to the design challenge.** Help students connect what they have learned to the design challenge. **Ask:** *Why was it important for the apprentice to use the king's foot?* (So the bed was the right size.) **Ask:** *Why did their feet* (measuring tool) *need to be the same size?* (Because what they were building should be of the same size.) **Ask:** *If we think about the toy boxes and organizers that we will be building for the toy company, do we need the same-size measuring tools for those too? Why?*

TEACHER NOTES

Lesson 2B

Name_____

Story Structure

Directions: Use words or draw pictures to answer the questions.

Who are the main characters?

When did the story take place?

What was the problem?

Why was there a problem?

How did they solve it?

Lesson 3A

FOCUS/KEY CONCEPTS

Students will be able to:

- **Mathematics:** understand that different measuring units produce different results.
- **Mathematics:** understand that for individuals to have an idea of the quantity or attribute measured, there should be a common unit of measurement, a "standard unit".

STANDARDS

National

CCSS-MC: 2.MD.A.2, 2.G.A.3

MATERIALS

- **Per student:** Measuring Tools worksheet, Engineering Design Process sliders
- **Per pair:** Measuring tool bags with arbitrary units, common measuring tool, toy boxes, Grid Paper worksheet
- **Per class:** Unit comparison chart, Talia's Letters/ Emails

TEACHER PREPARATION

- Prepare measuring tool bags with arbitrary units.
- The bags should each contain a different arbitrary object that can be used to measure the length of their toy boxes.
- Unit comparison chart: Create a table with two columns (on chart paper, whiteboard, etc.), one for arbitrary unit and the other for the number of times the unit was used to measure the length of the toy box.

Standard vs. Non-Standard Units

LESSON SUMMARY

In the first part of this STEM+C lesson, students will measure a fixed distance, the length of the inside of the Travel With Me Toy Box, using different arbitrary units (unit cubes, glue sticks, and paper clips). The teacher will collect and record each pair's measurement in a class data table. The idea is for students to further explore the concept of using different arbitrary units and how that will produce different results when measuring a fixed object. In the second part, students will create a common or "standard" measuring tool as a class that they will use to measure the same fixed distance. This lesson continues to build mathematical knowledge students will use to communicate information about their design plan to their client.

INTRODUCTION

1. **Introduce the concept.** Hold up a medium-sized object. **Ask:** *How big is this object?* Allow students without physically measuring the object to use their own words to describe how big the object is. Record these "measurements" on the board, under the name of the object. Present a second object that is of a different size. **Ask:** *How big is this object?* Again allow students without measuring to describe the size of the object in their own words. Record these "measurements" on the board, under the name of the object. Point out that although they were all describing the same objects, they used a number of different words to describe it. **Say:** *Think back to Susie and her Treasure Hunt, what was her problem?* (They were all using different tools to measure). *What happened when they all used different foot lengths, or different "tools?"* (They got different measurements.) Let's explore this idea a little more and see why it is important that we all use the same measuring tools.

2. **Tie to engineering challenge.** **Say:** *Let's think about our design challenge. Why can't we just use words like the ones we put on the board* (example: "medium-sized," "about the size of…," etc.) *to communicate our design plan to Talia?* (Take student responses.)

3. **Identify where they are in the engineering design process. (Learn)** **Ask:** *Where do you think we are in the engineering design process?* (Point to the classroom Engineering Design Process chart.) *Where should we move our paper clip and why should we move it there? (Learn about the problem phase.)* **Say:** *We are learning about why measurement might be important in our design challenge.*

ACTIVITY - Standard units of measurement

4. **Introduce the activity.** *Let's see what happens when we use different measuring tools. I am going to pass out a bag, and in the bag you will find an object that you will use to measure the length of the inside of your toy box.* Demonstrate how to measure across the longest part of the toy box with their tool. Pass out the toy boxes, bags of measuring tools, and **Measuring Tools worksheet**. Have the following table ready:

Unit	Measurement

Standard vs. Non-Standard Units

5. **Measure.** In pairs, let students measure the length of the inside of their toy boxes using one of the arbitrary units. Have students draw their measuring tool and record the length of the toy box using that tool on their worksheets. Observe students work to ensure that they are measuring accurately and then record their values in the chart.

6. **Discuss.** When students have finished measuring, ask each of the groups to share how many of each tool it took them to measure. **Ask:** *When we all used different measuring tools, we got different answers. What will happen if we use the same measuring tool?*

7. **Measure again.** As a class, decide on a common measuring tool that everyone can use to measure the length of the inside of their toy boxes and whose results will be understandable to all students in the class. Have students measure their toy boxes using the same tool. Have students draw the chosen measuring tool and record the length of the toy box using that tool on their worksheets. Compare the results that each of the groups got when using the same measuring tool.

CLOSURE

8. **Tie back to the engineering challenge.** Have students think about the toy box organizer challenge. **Ask:** *If we are designing a toy box organizer for Talia's Toy Box Company, why is it important for us to use the same measuring tool?* (So we can give the correct or same measurements to the toy box company. It will help them know how much material to use when building the organizers and the length of each part.)

9. **Introduce the grid paper.** Explain that Talia has asked us to use grid paper as our measurement tool. (Pass out the **Grid Paper worksheet**). Ask students to place their toy box on top of the grid paper. What do they notice? (The dark line is the same size as their toy boxes!) Then ask students to count how many squares they have for the length and width. (It should be the same.) They will use these squares to help communicate information about their toy box organizer designs to Talia.

TEACHER NOTES

Lesson 3A

VOCABULARY

- **unit** An amount used again and again to measure something

Lesson 3A

Name_____

Measuring Tools

Draw your measuring tool here.

My measuring tool is a:

How many did you need for the length of the toy box? _____

Draw the class measuring tool here.

Our class measuring tool is a:

How many did you need for the length of the toy box? _____

Grid Paper

Name_____

Lesson 3B

Measuring Penny

FOCUS/KEY CONCEPTS

Students will be able to:

- **Literacy:** compare and contrast measurements.
- **Science:** identify different attributes that were measured.
- **Mathematics:** understand that attributes can be measured in different ways using either standard or non-standard units of measure.

STANDARDS

National

- CCSS-ELA: RL.2.3
- CCSS-MC: 2.MD.A.1, 2.MD.A.4

MATERIALS

- **Per student:** Compare and Contrast worksheet, Engineering Design Process sliders
- **Per class:** *Measuring Penny* by Loreen Leedy

TEACHER PREPARATION

- Prepare one large copy of the compare/contrast chart (on chart paper, overheard, SMART board, etc.)
- Have one copy of the Engineering Design Process chart for whole class use.

VOCABULARY

- **unit** An amount used again and again to measure something

LESSON SUMMARY

In this literacy lesson, students will listen to a story titled *Measuring Penny* by Loreen Leedy in which the main character, Lisa, decides to use her dog, Penny, as the subject for her measuring homework of using standard and non-standard units. This story helps to review what students have learned in the previous STEM+C lesson by exploring multiple ways to measure a variety of objects while working on the comprehension skill of comparing and contrasting. Students continue to be introduced to the idea that there are different measuring units (standard and non-standard) as the main character explores a number of different measurements including length, weight, volume, time, temperature, and money. At the end of the activity, students will continue to develop their understanding of why standard units are important for measurement. This is a key mathematical concept students will use when creating and communicating their design plan. Reading strategy: comparing and contrasting.

INTRODUCTION

1. **Tie to engineering challenge.** Have the students explain the engineering design challenge in their own words. If necessary, reread Talia's letter/email.

2. **Identify where they are in the engineering design process. (Learn)** **Ask:** *Where do you think we are in the engineering design process?* (Point to the classroom Engineering Design Process chart.) *Where should we move our paper clip and why should we move it there?* Have students remind you of what they have done so far to help them get ready for designing their toy box organizer. (Developed understanding of ways to measure with examples from Susie's Treasure Hunt, *How Big is a Foot?*, and measuring items in the classroom.) **Say:** *We're going to continue to learn about measurement so we can create better plans for our toy box organizers.*

ACTIVITY - Compare and contrast

3. **Introduce the book.** Have students gather on the floor. Introduce the book, *Measuring Penny* by Loreen Leedy.

4. **Introduce/Explain the reading strategy and why it is useful.** Tell students they will be working on comparing and contrasting. Pass out and introduce the **Compare and Contrast Measurements worksheet** and how they will use it during the reading. Explain that as you are reading they are to record the unit Lisa uses to measure Penny and other dogs. After you finish reading, you will talk as a class about how Lisa's different ways of measuring are similar or different.

5. **Read the story aloud.** While reading, use the following to guide the lesson development process:
   - Teach new vocabulary at the point of contact.
   - Target the measurement types by having students record Lisa's different manners of measurement as you read.
   - Make sure to read the words within the pictures as well.
   - Encourage higher-level thinking and monitor comprehension by

pausing for "teacher think alouds" and asking questions about the text.

6. **Whole group practice.** After reading *Measuring Penny*, compare and contrast Lisa's different ways of measuring. For example, **Ask:** *Were noses measured the same as tails?* Have the students identify why they were similar or different. Pick out a few more to compare and contrast.

7. **Whole group instruction.** Help students decide whether each measure in their table is a standard or non-standard unit.

CLOSURE

8. **Tie back to the engineering challenge.** Remind students that we are learning about measurement to help us solve our engineering design problem. The ideas we are learning will help us with planning and communicating our design plans.

TEACHER NOTES

Lesson 3B

Name_____

Compare and Contrast Measurements

Directions: Record the unit Lisa used to measure each thing listed in the table. Then mark if the measure is a standard or non-standard unit.

	unit used to measure	standard unit	non-standard unit
noses			
tails			
ears			
paws			
height			
jump			
weight			
water			
food			

Lesson 3B

Name_____

Compare and Contrast Measurements

1. What happened in the story?

2. Why was Lisa measuring things?

3. Do you think Lisa did a good job with her homework? Why or why not?

4. What do you notice about the measures marked as non-standard units?

Lesson 3B Compare and Constrast Measurements

Directions: Record the unit Lisa used to measure each thing listed in the table. Then mark if the measure is a standard or non-standard unit.

	unit used to measure	standard unit	non-standard unit
noses	*inch*	X	
tails	*dog biscuit*		X
ears	*cotton*		X
paws	*centimeters*	X	
height	*inch*	X	
jump	*Lisa*		X
weight	*pounds*	X	
water	*cup*	X	
food	*cup*	X	

Lesson 3B Compare and Contrast Measurements

1. What happened in the story?

Penny measures her dog, Penny and other dogs from the park to complete her homework assignment.

2. Why was Lisa measuring things?

Lisa's teacher gave her class a homework project to measure something.

3. Do you think Lisa did a good job with her homework? Why or why not?

I think Lisa did a good job with her homework. She used non-standard and standard units consistently.

4. What do you notice about the measures marked as non-standard units?

The non-standard units results would be hard to duplicate if you did not have what Lisa used. A different non-standard unit was used every time. Hard to determine how big the non-standard unit is.

Lesson 4A

Living Color

FOCUS/KEY CONCEPTS

Students will be able to:

- **Science:** recognize that living things are very diverse.
- **Literacy:** identify the purpose of the text and the author's meaning.
- **Literacy:** identify how images contribute to and clarify the text.

STANDARDS

National

- CCSS-ELA: RI.2.6, SL.2.2

MATERIALS

- **Per student:** What Does the Color Mean? graphic organizer, Engineering Design Process sliders
- **Per class:** *Living Color* by Steve Jenkins

TEACHER PREPARATION

- Prepare one large copy of the What does the color mean BLM (on chart paper, overheard, SMART board, etc.).

VOCABULARY

- **diversity** A variety or range of differences

LESSON SUMMARY

In this literacy lesson, the book *Living Color* by Steve Jenkins is used to explore different animals based on their color. While students learn about brightly colored species and the many purposes behind their coloring, this book also sets the stage for sorting objects using the physical property of color. This lesson serves as an introduction to the next STEM+C lesson where they will do a hands on exploration of physical properties. Reading strategy: identifying the main purpose of a text.

INTRODUCTION

1. **Tie to engineering challenge.** Continue to tie students' learning to the engineering design challenge. **Ask:** *What is our final design challenge?* (To design a toy box organizer.) *How will we know that we have a good design?* (The toys stay in place, the toys can be found and removed in less than 5 sec, and other tests you may have defined.)

2. **Identify where they are in the engineering design process. (Learn)** **Ask:** *Where do you think we are in the engineering design process?* (Point to the classroom Engineering Design Process chart.) *Where should we move our paper clip and why should we move it there?* **Say:** *When we design our organizers we are only going to be able to use a few different materials. To help us make good choices we are going to explore the different properties of these materials to determine which one we think will be best for our toy box organizer. Today we are going to be learning about physical properties and the properties of the materials that we are going to be able to use.*

ACTIVITY - Identifying the main purpose of a text

3. **Introduce the book.** Introduce the informational text, *Living Color* by Steve Jenkins. **Say:** *To help us learn about these physical properties we are going to be reading an informational text called* Living Color *that explores the property of color and why color is important for helping animals survive.* **Ask:** *Who can think of an animal and what color it is?* (Take some student answers.) **Say:** *Let's read and find out about some of these animals, and how their color helps them survive.*

4. **Introduce/Explain the reading strategy.** Read the **FIRST** page of the book, then **PAUSE** to explain the strategy. **Say:** *Learning to identify the main purpose of the text you are reading, including what the author wants to answer, explain, or describe through the text, is very important. You will be looking for important details on each page* (show them the graphic organizer) *by identifying the color, one of the animals and why that color is important to that animal or what the color tells you. For example, the color red in a Scarlet Percher Dragonfly tells you that it is all grown-up.*

5. **Start reading.** Continue reading through this book and remember to use some of the strategies that help with reading and comprehension development:
   - Teach new vocabulary at the point of contact.
   - Target the reading skill – summarizing the informational text.

- Encourage higher-level thinking and monitor comprehension by pausing for "teacher think alouds" and asking questions about or discussing the text.

6. **Re-read and practice.** Pass out the **What Does the Color Mean? graphic organizer**. Go back and re-read selected pages to have students practice identifying the color, animal, and what that color tells you about that animal. Once you have finished reading and identifying the color, animal, and purpose for the color on the graphic organizer, **ask:** *Now that we have identified some of the details about colors and animals, what do you think the author is trying to tell us throughout this book?* Either as a class, with a partner, or on their own, help students complete the bottom question on the worksheet, which gets at the strategy of identifying what the author is trying to describe or explain throughout this book.

CLOSURE

7. **Post-Reading: Connect to STEM lesson**. At the end of this reading, leave enough time to have a short discussion of the story and to be able to connect this knowledge to the activity they will be doing in the STEM lesson. For example, **say:** *In the book, it talked about how animals use color. Color is one of the physical properties that can be used to describe objects or things.* **Ask:** *How else do you think you can describe an object?*

8. **Tie back to the engineering challenge.** It is important to connect this reading with the lesson they will be completing during their STEM lesson and back to the engineering design challenge. For example, **ask:** *Now that we learned about the importance of the property of color, we are going to learn about other properties and how they can be useful when thinking about the materials we can use in our designs.*

TEACHER NOTES

Lesson 4A

Name_____

What Does the Color Mean?

Animal	Color		Purpose of the color
		→	
		→	
		→	
		→	

What is the author trying to tell us about animals and color?

_____

_____

_____

_____

Lesson 4B

Investigating Properties

FOCUS/KEY CONCEPTS
Students will be able to:
- **Science:** demonstrate an understanding of physical properties of objects by using these properties to sort and describe given objects with peers in collaborative conversations.

STANDARDS
National
- NGSS: 2-PSI-1
- CCSS-ELA: SL.2.1

MATERIALS
- Object (see Step 3)
- Physical Properties chart paper
- Physical Properties bags (one per student)
- Mystery bags (one per pair)

TEACHER PREPARATION
- **See 4B Teacher Preparation Instructions**

VOCABULARY
- **engineer** A person who applies science, mathematics and creativity to solve a problem to meet a need or want.
- **property** An attribute, quality, or characteristic of something

LESSON SUMMARY

In this STEM+C activity, students learn about using physical properties to sort and describe different objects. In the first part of the lesson, students learn about size, shape, weight, texture, flexibility, and strength as well as how these physical properties can be used to describe objects and the materials that they are made out of. After building some familiarity with these properties by sorting and describing a variety of objects, students will move into the second part of the activity, where they practice using these properties to describe an object in their mystery bag. Students will use this background knowledge to help them make choices about how they arrange the toys and which materials they will use to build their toy box organizer.

INTRODUCTION

1. **Tie to engineering.** Have students recall the engineering design challenge in their own words.

2. **Identify where they are in the engineering design process. (Learn)** Instruct students to look at their Engineering Design Process slider. **Say:** *We are working in the learn about the problem phase.* Inform students that they are continuing to work on the background knowledge needed to build their toy box organizers.

3. **Introduce the investigation.** Hold up an object. **Say:** *Pretend that you are talking to a friend on the phone, and you want to describe this item to them. What words would you use describe the item?* Remind students that the friend cannot see the object. Using the **Physical Properties chart paper** record students' answers under the correct headings (examples: "white" under the "color" heading or "circular" under "shape" heading).

4. **Investigate material properties.** **Ask:** *Who noticed that I placed your answers in certain places on the chart paper? I was sorting them according to titles that I have hidden under these sticky notes. I want you to look closely at the groups I placed the words in. What similarities do you notice about the words that have been grouped together? NOTE: If students look confused, prompt them to look at the "color" column and tell you what they notice about all of the words. Once students get the color column title, ask them about the other titles. If students are less familiar with the titles, it might be necessary to scaffold by either proving extra words that fit in that group so they can guess the title or revealing the titles and then asking them to provide additional word that fit in the group. (Example: If you reveal "strength," you can ask students for words that describe the strength – strong, weak, etc.)* Explain to students that these titles are the names for physical properties that can be used to describe objects.

ACTIVITY - Physical Properties

5. **Introduce physical properties bags.** **Say:** *To practice using these new words, we are going to do a sorting activity with the materials in these bags.* Hold up a **Physical Properties bag**. *We are going to be sorting these materials by placing similar items together in a pile.*

6. **Sort materials and discuss physical properties.** Pass out the **Physical Properties bags** to each student and have them sort the materials. After students have finished sorting at least one way, have a few of them share how they sorted their materials. (For those students that have chosen to sort by physical properties, point to the heading that matches their sorting category.) After the initial sorting of materials, ask students to sort the materials using a physical property from the chart that they have not tried yet. Once students have had a chance to try sorting by physical properties on their own, choose a few to sort together as a class. To create a visual reminder of the physical properties on the chart, tape objects from the physical properties bags under the correct title and next to the word that it best represents. (Example: Place all of the objects that "bend" together under the title of "flexibility" and next to the word "bend.")

7. **Introduce mystery bags.** To spark their interest in the **Mystery bags**, **say:** *We will be doing an activity called* **Mystery bags**. *What do I mean when I use the word mystery? What is a mystery?* (Something that hasn't been solved.) **Say:** *Well, the mystery is that we don't know what is inside these bags but to solve the mystery we must follow these rules:.*
   - *At least two people need to work together.*
   - *One person will be the "looker." The "looker" is the only person who can look inside or touch the bag.*
   - *The other person/people are the "guesser(s)," and they are trying to guess what is inside without looking at it.*
   - *"Guessers" can only ask yes or no questions, and "lookers" can only respond "yes" or "no".*

8. **Practice asking yes or no questions.** **Say:** *Before we start trying to solve the mystery, let's review the types of questions we can ask. What is a yes/no question?* After reviewing yes/no questions, remind students that it will be easiest if they use some of their physical property words to help them describe and visualize what might be inside. (Example: Is the object red? Is it heavy? Can it bend?)

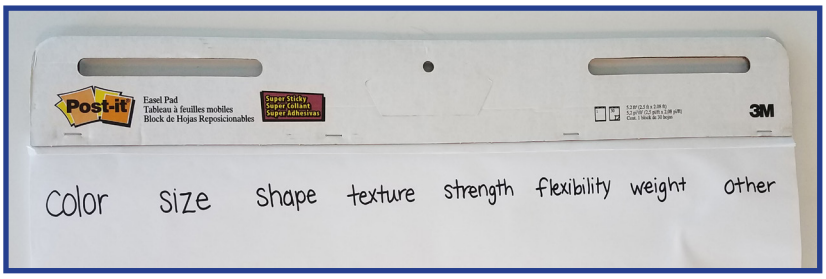
9. **Complete mystery bag activity.** Pass out a **Mystery bag** to each pair of students. Have students determine who will be the "looker" and "guesser." If time permits, reassign bags to pairs, so that each student has the opportunity to be the "looker" and "guesser."

CLOSURE

10. **Tie back to the engineering challenge** **Say:** *Today we learned about different physical properties of objects.* **Ask:** *Why is it important to be able to describe objects using these words? Why do you think it is important for an engineer to learn about the physical properties of different objects when designing something? Let's pretend we are engineers, when might it be helpful to use something that is strong, like a craft stick?* (Take student answers.) *Or soft and flexible like a pipe cleaner? (Take student answers.)*

TEACHER NOTES

Lesson 4B Teacher Preparation Instructions



Physical Properties Chart Paper

You will need:

- 1 sheet of chart paper
- 1 marker
- 8 sticky notes

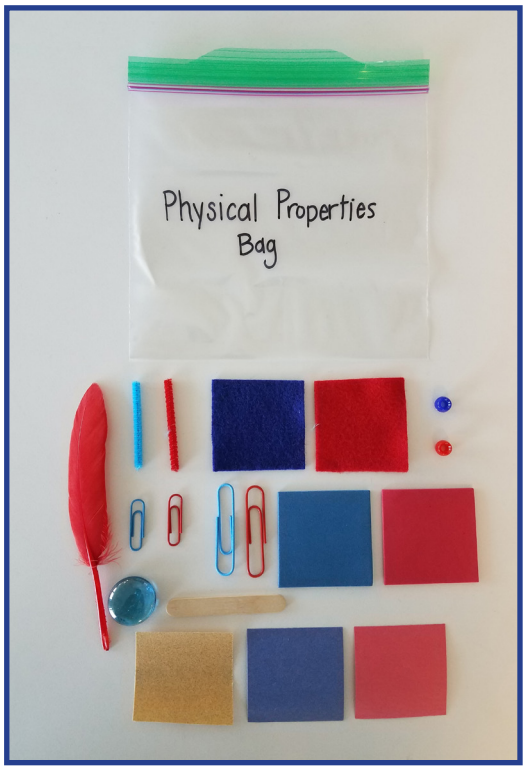
Instructions:

- Use a marker to write the following headings across the top of a piece of chart paper: color, size, shape, texture, strength, flexibility, weight, and other.
- Place the sticky notes over the words to cover the headings.

Physical Properties Bags

You will need:

- sandwich-size plastic resealable bag (#S)
- small feathers (one of the two colors used in the bag) (#S)
- glass gem/vase fillers (clear or one of the two colors used in the bag) (#S)
- craft beads (#S x 2)
- large paper clips (#S x 2)
- small paper clips (#S x 2)
- felt (2.5" x 2.5") (#S x 2)
- construction paper (2.5" x 2.5") (#S x 2)
- foam (2.5" x 2.5") (#S x 2)
- sandpaper (2.5" x 2.5") (#S)
- pipe cleaners (2.5" long) (#S x 2)
- mini craft stick (2.5" long, you can also cut a regular sized craft stick to measure 2.5") (#S)
- scissors and a ruler OR a paper cutter
- permanent marker



Note: Use the same two colors for the following items in each bag: beads, large and small paper clips, felt, construction paper, and foam. For example, a blue and red feather, a blue and red bead, a blue and red large paper clip, etc.

Instructions:

1. Gather all of the materials listed above. Each student will need their own bag.
2. Cut the felt, construction paper, foam, and sandpaper into 2.5" x 2.5" squares and cut the pipe cleaners (and if you are using regular-sized craft sticks) to 2.5" length pieces.
3. In each sandwich-sized plastic bag place two of each of the following items: beads, large and small paper clips, felt, construction paper, foam, and pipe cleaners and one of each of the following: feather, glass gem, sandpaper, and craft stick.
4. Write "Physical Properties" on the outside of each bag with a permanent marker.

Lesson 4B Teacher Preparation Instructions

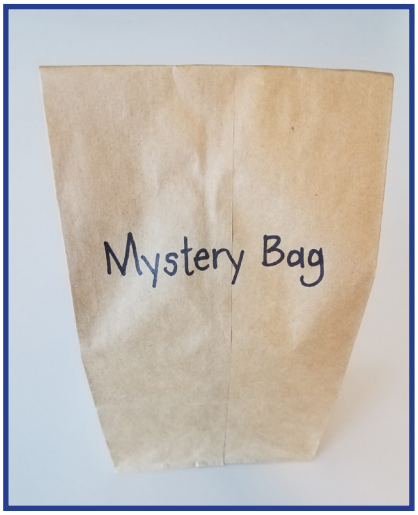
Mystery Bags

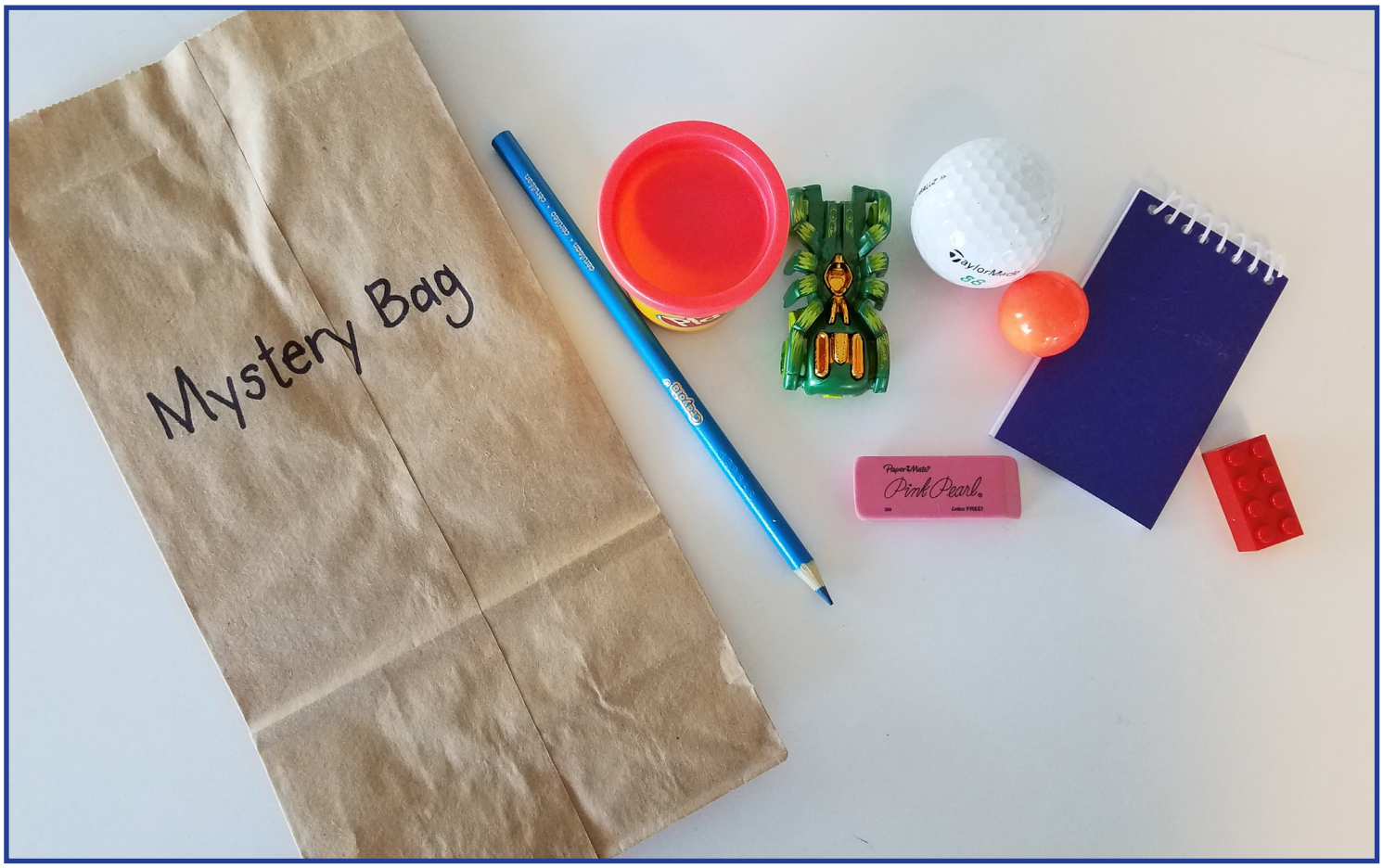
You will need:

- brown paper lunch sack (mini or regular-size) (#P)
- mystery item (use one of the toys from the toy box) (#P)
- permanent marker

Instructions:

1. Gather all of the materials listed above. Each pair of students will need a bag.
2. Use the marker to write "Mystery Bag" on the front of the lunch sack.
3. Place one "toy" in the lunch bag (e.g., Matchbox car, LEGO piece, golf ball, playdough, rubber ball, eraser, color pencil)
4. Fold down top of bag so students cannot see inside.





Lesson 5A

Rosie Revere, Engineer

FOCUS/KEY CONCEPTS

Students will be able to:

- **Literacy:** identify three cause-and-effect events from the story.
- **Literacy:** recount stories and determine their central message, lesson, and moral.
- **Engineering:** discuss the importance of testing materials before building a prototype.

STANDARDS

National

- CCSS-ELA: RL.2.2, SL.2.2

MATERIALS

- **Per student:** Cause and Effect graphic organizer, Engineering Design Process sliders
- **Per class:** *Rosie Revere, Engineer* by Andrea Beaty

TEACHER PREPARATION

- Prepare one large copy of the Cause and Effect graphic organizer (on chart paper, overheard, SMART board, etc.)
- Make copies of the Cause and Effect graphic organizer (one for each student)

LESSON SUMMARY

In this literacy lesson, students learn about how failure should not be a discouragement, but, part of the process, of engineering while listening to *Rosie Revere, Engineer* by Andrea Beaty. This story is about Rosie, who dreams of becoming an engineer. Students will be able to identify the cause and effect of the main events and the central message, lesson, or moral of the story. This lesson is important, because students may experience failure during the testing process. Reading strategy: identifying the author's message.

INTRODUCTION

1. **Tie to engineering challenge.** **Say:** *We have been talking about our final engineering design challenge. Who can remind me of this engineering design challenge and what we are trying to do?* (Take student responses.)

2. **Identify where they are in the engineering design process. (Plan)** Have students look at their Engineering Design Process slider. **Say:** *We are working in the plan the solution phase. Now that we know our problem and we have learned some background information about mapping, measuring and materials, we will continue to use that information as we move into the next phase of plan, try, test, and decide. Within the plan step, you will start to think of different ways that you can solve the problem (designing an organizer for our toy box to keep the toys from getting all messy) and then decide one solution you want to try and develop plans for that solution. We are going to be starting on our toy box organizer plans today, so we will be moving into the planning phase.*

3. **Connect to prior knowledge.** **Ask:** *Who has ever had a really great idea for something they wanted to create or invent? What was it and what did you do with that really great idea? Did anyone have a really great idea that they tried out and it didn't work out so well? What did you do then?* (Gather a few answers to help students begin to make connections to one of the underlying theme of the book – how to deal with failure.) **Say:** *Today we will read a story about a little girl, who has great ideas and loves making new things, but sometimes her great ideas don't go as planned. Let's see what happens to our friend Rosie and her good ideas.*

ACTIVITY - Author's message

4. **Introduce the book.** **Say:** *Today, we will be talking about engineering. We are going to be learning about Rosie Revere, who is an engineer, what she does with her good ideas, and how she makes a flying machine for her great-great aunt Rose.*

5. **Introduce/Explain the reading strategy.** **Say:** *This is a fiction book. It is a story that the author created to tell us about an important message. After we have finished reading the book, I want you to see if you can determine what that message is. We are also going to continue to work on becoming good readers by looking at how we can use cause and effect to help us remember some of the things that Rosie does in the story.*

6. **Start Reading.** Read the book aloud and remember to use some of the strategies that help with reading and comprehension development:
   - Teach new vocabulary at the point of contact.
   - Target the reading skill – summarizing the informational text.
   - Encourage higher-level thinking and monitor comprehension by pausing for "teacher think alouds" and asking questions about or discussing the text.

7. **Re-read and practice.** Pass out the **Cause and Effect graphic organizer**. Now that you have read the story, have students help you recount the story by identifying the cause an effect of the main events from the story. Here is an example of what you might include for the cause-and-effect chart:

cause	effect
Rosie made a cheese hat for her uncle Fred and he laughed at her.	She kept her ideas to herself (hid her inventions under the bed).
Rosie made a cheese-copter for her Great-Great-Aunt Rose.	It didn't work and her Great-Great-Aunt Rose laughed at her. Rosie felt sad.
Rosie's first cheese-copter failed.	Her Aunt Rose helped Rosie see that failure is a good first step.
Aunt Rose gave her a notebook and they made a plan.	They worked together on different designs until they got one that worked.
The second graders at Blue River Creek fail on their inventions.	They stand and cheer.

8. **More practice - Author's message.** Ask students to determine what they think was the central message, lesson, or moral of the story by completing the bottom of the worksheet.

CLOSURE

9. **Tie back to engineering challenge.** At the end of this reading, leave enough time to connect this learning to the activity they will be doing in the STEM lesson and back to the engineering design challenge. **Say:** *Today we will be working like engineers and moving into the planning phase with designing our toy box organizers. Why do you think we read about Rosie before we started on our designs?* (Sometimes our designs don't work out the first time.) *What did Rosie's Aunt Rose tell her after her cheese-copter didn't work?* (That it was a great first try and "the only true failure can come if you quit.")

TEACHER NOTES

Lesson 5A

Name_____

Cause and Effect

Directions: Use words or draw pictures to complete the graphic organizer.

cause (what happened)		effect (the result)
	→	
	→	
	→	
	→	

What is the moral of this story?

_____

_____

_____

Lesson 5B

FOCUS/KEY CONCEPTS

Students will be able to:

- **Engineering:** investigate material's properties to determine how it will function to build a prototype.
- **Literacy:** listen to others, explain, and take respectful turns building on comments of others.

STANDARDS

National

- NGSS: 2-PS1.1, K-2-ETS 1-1, K-2-ETS 1-2
- CCSS-MC: 2.G.A.2
- CCSS-ELA: SL.2.1. A-C

MATERIALS

- **Per student:** Individual Materials List, Individual Planning Sheet, Engineering Design Process sliders
- **Per pair:** Team Materials Lists, Team Planning Sheets, toy box, set of toys, Sample Materials Bags

TEACHER PREPARATION

- Prepare Sample Materials Bags
- Prepare a set of toys for each group.
- Prepare one toy box with a set of loose toys.

VOCABULARY

- **engineer** Uses mathematics, science, and creativity to solve problems to help people

Plan a Solution

LESSON SUMMARY

In this STEM+C lesson, students will apply the science and mathematics knowledge they have learned in previous lessons to help them design a toy box organizer. First, students will review the criteria and sort the toy box toys and building materials. Then, they will create a design plan individually and then as a team.

INTRODUCTION

1. **Tie to engineering challenge.** Point to the location your class has recorded the problem and **say:** *Here is where we recorded the problem. Listen as I read the engineering design challenge again. Think about the problem we are trying to solve and if we have accurately described it.* Re-read the letter/email from Talia. **Ask:** *Thinking about the design challenge that we just listened to, did we correctly describe the problem that we are trying to solve or should we add to what we have written?* (Add to students' answers if necessary.)

2. **Identify where they are in the engineering design process. (Plan)** Have students look at their Engineering Design Process slider. **Say:** *We are working in the plan the solution phase. When planning, we should keep in mind what we know about the problem and what we learned about measurement and physical properties of materials. As we plan, it is ok to go back to ask and learn if we need more information.*

ACTIVITY - Sorting and planning

3. **Introduce the activity.** Review the project criteria. **Say:** *Talia told us she wants an organizer for the Travel with Me Toy Box* (hold up a sample box), *so our organizer has to fit and work inside of this toy box. She has also sent a sample of the types of toys that she would like for you to organize.* Hold up the bag of toys. Pull out and place each of the items into the toy box as you say what they are. **Say:** *I have put all of these items into my toy box, what do you think will happen to the toys in my toy box when I put the lid on top and walk around with it?* Take student guesses. Then walk around while swinging the toy box as you walk. Take the lid off and show students what it looks like. **Ask:** *Do you think that it would be easy to find exactly what I need in this toy box?* (No.) **Say:** *As it is now it, is not a good design for keeping the toys organized. If this is not a good design, let's remember what we said would make a good design. Do we need to add anything else to this list?* (Take some student ideas.) We will test the organizer inside the toy box to see if it keeps the toys organized. Here is one way we decided to test to see if it is a good design.

4. **Review tests.** Show students that each of the toys are pictured on the **Quality Control Cards.** Explain that in order to complete the Grab test teams will have to secure the lid on the toy box. Then, they will select one card. Once the timer starts, the teacher will have to open the toy box, locate all of that type and pull them completely out in five seconds or less. Review other ways you decided to test the designs. Record new ideas agreed upon as a class. **Say:** *Now that we know how the toy box organizer is going to be tested, we are almost ready*

to design. But there is one more thing that we want to consider. In our previous STEM lesson we learned about physical properties. Better understanding the toys and building materials will help us create better plans. Have students recall the physical properties discussed in Lesson 4B. Then **ask:** *Remember how we sorted the materials in our bags from yesterday* (hold up physical properties bag)*? We are going to do the same thing with our toys.*

5. **Sort the toys.** Pass out a **Set of Toys**. Have students think of a couple ways to sort the toys. Then ask groups to talk about how they sorted the toys and what they noticed about the properties of the different groups of toys. Create a Toy Properties Table as a class. Go over some of the properties together and talk about what that means for their toy box designs. For example, the balls and beads are round. What does that mean for when you put those toys into your toy box? Or, the beads are really small, so what does that mean?

6. **Sort the materials.** **Say:** *Now that we know about the properties of the toys, let's look at some of the properties of the materials that we can use to build our organizers.* Pass out the **Sample Materials Bags**. Create a Sample Materials Bag Table as a class. After filling out the table, ask questions that help students think about how certain properties are good and bad for different parts of the organizer. For example, why might it be nice to have something that is flexible, like the pipe cleaners or the foam? Why might it be not so good to use something like paper? What about something that is strong, like the craft sticks. Why could they be good? Why could they be bad?

7. **Plan.** Provide students with **Planning Sheets** including the **Individual Planning Sheet** to each pair. Remind students that the outline of the grid on the Individual Planning Sheet is the same size as the inside of the toy box. Have students brainstorm (on their own) some different ways they might want to organize the toys in their toy box. After giving them some time to think about it, have students individually create at least one plan. Once students have developed some ideas for the organizer, have them go back and start on their plan with their partner. Pass out **Team Planning Sheets** and **Materials List**. Tell students that tomorrow they will be building, so, in order to get the materials that they need from the materials store they need to complete both the **Team Planning Sheet** and **Materials List**. The plan must include where the toys will go (name and/or drawing) and a picture of the organizer with parts labeled with what they are and what they are made out of. The Materials List needs to tell how much of each material the team needs. They can determine this by counting up the total length in squares of each material listed on their plan.

CLOSURE

8. **Tie back to the engineering challenge.** Have students think about how their ideas will help the toy company. Ask them to justify their ideas for how to arrange the toys and which materials they will use in their designs.

TEACHER NOTES

Lesson 5B

Name_____

Individual Materials List

Directions: Circle the materials you want to use for your organizer. Explain why.

aluminum foil		
tissue paper		
construction paper		
pipe cleaners		
string		
craft sticks		
foam sheets		

Individual Planning Sheets - Idea # ___

Name_____

Team Planning Sheet - Prototype # ____

Name_____

Lesson 5B

Name_____

Team Materials List - Prototype # ☐

Directions: Find the total length of each material you need by counting the squares on your Planning Sheet. Record the total in the table below.

materials	total # of squares long
aluminum foil 	_____ squares long
tissue paper 	_____ squares long
construction paper 	_____ squares long
pipe cleaners 	_____ squares long
string 	_____ squares long
craft sticks 	_____ squares long
foam sheets 	_____ squares long

Lesson 5B Quality Control Cards

Directions: Cut out the Quality Control Cards. Laminate the cards and trim around the edges.

toy car 	**building blocks** 	**golf ball** 
crayons 	**colored pencils** 	**paper pad** 
stickers 	**beads** 	**playdough** 
eraser 	**bouncy ball** 	

Lesson 6A

Too Many Toys

FOCUS/KEY CONCEPTS

Students will be able to:

- **Literacy:** identify main events in the story, and how the main character responds to these events.
- **Literacy:** summarize a story (narrative text) by identifying one sentence to represent the beginning, middle, and end.

STANDARDS

National

- CCSS-ELA: 2.3, SL.2.2

MATERIALS

- **Per student:** Summarizing the Story graphic organizer, Engineering Design Process sliders
- **Per class:** *Too Many Toys* by David Shannon

TEACHER PREPARATION

- Prepare one large copy of the Summarizing the Story graphic organizer (on chart paper, overheard, SMART board, etc.)
- Optional: Copies of the Summarizing the Story graphic organizer (one for each student)

LESSON SUMMARY

In this literacy lesson, the teacher will read aloud *Too Many Toys* by David Shannon to help reinforce the context for why a parent and child might need a way to organize toys. The story is about Spencer, a little boy who has too many toys. Spencer's mom finally has enough with all of his toys and tells him that he needs to clean up his toys and put some into a box to get rid of them. Reading strategy: summarizing narrative text.

INTRODUCTION

1. **Tie to engineering challenge.** **Say:** *Yesterday, you started planning a solution to the engineering design challenge where you are going to be helping Talia by designing a toy box organizer that will help keep toys in their place and easier to find when stored in her travel-sized toy box.*

2. **Identify where they are in the engineering design process. (Learn/Plan)** Have students look at their Engineering Design Process slider. **Say:** *We are working in the learn about the problem and plan the solution phase.* In this book, the main character will plan and solve a problem. **Say:** *Yesterday, we talked about how it is important to test our materials and how engineers do that before they start to create their designs. As we are reading this story about Spencer and his toys, I want you to be thinking about what problem Spencer has and how he solves this problem.*

ACTIVITY - Summarizing Narrative Text

3. **Introduce the book.** Have students gather on the floor for as you introduce the story *Too Many Toys* by David Shannon.

4. **Introduce/Explain the reading strategy and why it is useful.** As you introduce the strategy of summarizing a story, tell students that as good readers this is something they will need to do when telling their parents or a friend about a book they have read. The person they are talking to won't need to hear every detail about the story, and so they want to tell them just the most important points from the story. **Say:** *If you were telling a parent or friend about this story, you don't want to tell them every detail, but instead, you just want to give them the most important points. We do this when we summarize, we tell the important ideas that happen at the beginning, middle, and end of the story.*

5. **Model the comprehension strategy.** Summarizing is a difficult skill, so you can use the story from Lesson 4A to model how students can summarize a text. The focus of the previous lesson was to recount events from the story, so this should be familiar to them. **Say:** *Today we are going to practice summarizing the book* Too Many Toys. *Before we do that, let's practice by summarizing Rosie Revere, Engineer. When I summarize, I first want to give a sentence about the beginning of the story that tells about the characters, setting, and problem.* Give a summary sentence about the beginning of Rosie Revere in your own words and talk aloud as you explain how you came up with that sentence. **Say:** *Next, I will give a sentence that*

tells about the middle of the story, and I will talk about the problem that Rosie faced. Again, talk aloud as you give a sentence for the middle of the story. **Say:** *Finally, I will give a sentence about the end of the story that tells how the problem was solved.* Talk aloud as you give a sentence for the end of the story.

6. **Start reading.** As you are reading through the story, remember to pause and use some of the things that help their development as good readers:
   - Teach new vocabulary at the point of contact.
   - Target the comprehension skill – main ideas from informational text.
   - Encourage higher-level thinking and monitor comprehension by pausing for "teacher think alouds" and asking questions about the text.

7. **Whole group practice.** Once you have finished reading the story, remind students that the purpose of summarizing is to help readers to better understand and remember stories. You can define summarizing as stating important ideas that tell what happens at the beginning, middle, and end of a story. Pass out the **Summarizing the Story graphic organizer**. Since summarizing is such a difficult skill, the first part of the worksheet focuses on identifying the main events from the story, and how Spencer responds to those main events. This will help students think about what is happening at the beginning, middle, and end of the story, which will help them with the bottom half of the worksheet looking at summarizing the story. As a class, identify the main events and record them on the graphic organizer.

8. **Individual practice.** Once you have completed the top half of the worksheet, have students summarize the story by writing three sentences that explain what happened at the beginning, middle, and end of the story, using the boxes to help them.

CLOSURE

9. **Share responses.** Once you have completed the story, have students share what they wrote and then combine their answers to create a single summary for the beginning, middle, and end of the story. Tell students that another important part of summarizing is thinking about the author's message and ask them what they think the message of this story might be.

10. **Tie back to engineering challenge.** To engage the students in higher level talking about text, ask students why they think we might have read this story about Spencer and his toys when working on our engineering design challenge.

TEACHER NOTES

Lesson 6A

Name_____

Summarize the Story

Recall Main Events

1. beginning

		What does Spencer do?
Spencer gets a lot of toys	→	

2. middle

	→	

3. end

	→	

4. Summarize. Put the three parts together into a paragraph.

_____

_____

_____

_____

_____

_____

Lesson 6B

A Solution for Talia

FOCUS/KEY CONCEPTS

Students will be able to:

- **Engineering:** identify the problem and describe how their design solves the problem.
- **Literacy:** participate in collaborative small group conversations and give and follow multi-step directions.
- **Engineering:** develop a drawing to illustrate how their prototype solves an identified problem.
- **Engineering:** students analyze their prototypes and compare strengths and weaknesses of their first and final models (or compare to other groups' prototypes).

STANDARDS

National

- NGSS: K-2-ETS1-1, K-2-ETS1-3
- CCSS-ELA: SL.2.1.A- B, SL.2.3, SL.2.4, SL.2.6, RI.2.7

MATERIALS

- **Per student:** Planning and Material Sheets (from 5B), final Letter/Email to Talia, Engineering Design Process sliders
- **Per pair:** Set of toys, toy box, building materials
- **Per class:** Thank You Letter/Email, extra building materials, quality control cards, masking tape, camera, scissors

TEACHER PREPARATION

- Prepare one box with toys for each group.
- Prepare the materials for each group by cutting their materials into the requested sizes.

LESSON SUMMARY

In this STEM+C lesson, students use their team design plan to build and test an organizer for their toy box. This is an important part of the engineering design process as they find out what parts of their design work and what parts do not. After students share their designs and results, they will have the opportunity to redesign their toy box organizer. Finally students will use what they learned and work on their communication skills to write a letter back to Talia explaining their solution to her toy box problem.

INTRODUCTION

1. **Tie to engineering challenge.** **Say:** *Now that we have read about Spencer and his toy problem, let's revisit the engineering design process and our design challenge. We said that the engineering design process is a set of steps used by engineers to help them think about and solve problems. Then we talked about our problem.* **Ask:** *Who can remember what problem we are trying to solve?* (Create an organizer to make it easy to find the toys within the toy box.) **Ask:** *Then we started working on our engineering design challenge, who can remember what we did?* (We talked about the properties of the toys and materials that we can use and came up with our group plan and a list of the materials that we need to build our toy box organizer.)

2. **Identify where they are in the engineering design process. (TRY then TEST)** Have students look at their Engineering Design Process slider. **Say:** *Today we will be working in the try the solution and test the solution phases.* **Say:** *In the last lesson, we completed an important part of our design challenge, which was the planning step. Now that we have good plans and have thought about our designs, are you ready to try (build) and test them?* Prepare students for the idea that their toy box organizer designs might not work the first time, and failure is a part of engineering. As engineers, they will be redesigning their toy box organizers to make them better. Have students move their slider throughout the work in this lesson to match what they are doing at that time. Move the slider now to TRY.

ACTIVITY - Try and test solutions

3. **Introduce the activity.** **Ask:** *I know that you all have an idea of how you will build your designs, but who can remember how we are going to test your designs?* Have students share and explain the agreed upon tests.

4. **Moving from Plan stage to Try stage.** Remind students that if they did not finish their group plan, then they will need to finish that and get it cleared with you before they start building.

5. **Collecting materials.** After students have completed their group plan and materials list, they will go to the "materials store" to get their building materials. After retuning with the supplies, they can set out to build their design with their partner. Remind students that it should look like the plan they drew with their group, and that it is ok even if it is not working exactly as they thought it will.

6. **Testing (TEST).** Once students have finished building, they are ready for testing their toy box organizers. It might be helpful to have a signal for students who are ready to test, or you can have them bring their organizer prototypes inside a toy box over to a specific testing station. Before testing each group design, take a picture of their design, so they can remember it and use it to help them with their redesign and when sharing their designs with the class. Students should record their test results on the **Test Results - Prototype # (1)** sheet. After testing, take another photo of the organizer.

A Solution for Talia

Lesson 6B

VOCABULARY

- **redesign** Making corrections to an original design to make it better

ACTIVITY - Decide and redesign solutions

7. **Sharing designs (DECIDE).** **Say:** *We will be sharing our designs as a group. This is the decide phase: as we are trying to decide if our toy box organizers perform like we want them to.* Have students share their designs. After all of the students have created and tested their toy box organizers, allow students to share their designs with others, while reminding them to pay attention, because they might get ideas that they want to try in their redesign. This is where the pictures are helpful, because it can be easier for students to explain from a picture which materials they used and how their design fared during testing.

8. **Redesign of toy box organizers.** After finding things that did not work as well as they would have liked and hearing ideas from other groups, students can use what they learned in their redesign. Allow time for pairs to complete the **Redesign** graphic organizer and to redesign their toy boxes organizers. This will also give them a chance to fix anything that they might have forgotten during their first design. As they plan again, provide them with new copies of the **Planning Sheet - Team Plan for Prototype # (2)** and the **Materials List - Prototype # (2)** sheets from Lesson 5B.
   NOTE: Have students move their sliders to match their activities within the redesign and retest.

9. **Retest.** Provide a second copy of the **Test Results - Prototype # (2)** sheet. Allow students to test their designs in the same manner and take another picture, so that students can compare their first and second designs.

CLOSURE

10. **Decide between prototypes.** Have students look at and compare the pictures of the two designs and decide on the design that they think is best, and why they think that design is best. This will help students to reflect on their designs, and how well they met the criteria.

11. **Share decisions.** Have students share with their classmates the design they ultimately chose and why they chose that design. They should also prepare all the documents and information requested by Talia, so that their work can be shared with her.

12. **Individual communication with Talia.** Have students individually fill out the **Final Letter to Talia**. A teacher key is provided to help provide guidance for students. Collect the letters and tell the students you will send the letters and the test results, maps, materials list, and pictures to Talia.

13. **Present the thank you letter/email from Talia**. After time (perhaps a break or come back to this during a downtime later), tell students that you received a final letter/email from Talia. Present this to the students as a way to let them know that their engineering work was appreciated by Talia. Celebrate what you accomplished as a class.

TEACHER NOTES

Lesson 6B

Name_____

Test Results - Prototype

photo of toy box before testing	photo of toy box after testing

Test 1: Grab Test - Draw a card from the quality control card deck.

name of toy on card	Could the toy be removed in 5 seconds or less?	
	yes	no
	yes	no
	yes	no

Test 2: Shake Test - Place the lid on the toy box and shake it. Open the lid.

Number of items not in their correct location: _____

List the items not in their correct location: _____

_____

_____

Other observations: _____

_____

_____

Lesson 6B

Name_____

Test Results - Prototype

Test 3: _____

Test 4: _____

Lesson 6B

Name_____

Redesign

Directions: Use your test results to help you decide what improvements you want to make to your toy box organizer.

change you want to make to design	why you want to make the change		how the change will improve your design
		→	
		→	
		→	

Lesson 6B

Name_____

Final Letter to Talia

Dear Talia,

I have included the test results, maps, materials list, and pictures of my toy box organizer prototypes.

I suggest you use prototype # _____.

You should use this design because _____

_____

_____

The toy box organizer prototype met the following criteria:	Check if met
Helped keep the toys where they are supposed to be.	
Made it easy to find a particular toy.	
Fit inside the toy box.	
Allowed the lid to shut when it and the toys were inside the toy box.	

I claim that the toy box organizer met the criteria, because _____

_____

_____

_____

Signed,

_____

Lesson 6B

Name_____

Final Letter to Talia

Dear Talia,

I have included the test results, maps, materials list, and pictures of my toy box organizer prototypes.

I suggest you use prototype # _____. Students should enter the prototype number they think best solves Talia's problem

You should use this design because _____

Students should explain why the identified prototype is better than the other prototype(s) and talk about what is especially good about the design.

The toy box organizer prototype met the following criteria:	Check if met
helped keep the toys where they are supposed to be.	
made it easy to find a particular toy.	
fit inside the toy box.	
allowed the lid to shut when it and the toys were inside the toy box.	
Students should add the class-created criteria here.	

I claim that the toy box organizer met the criteria because _____

Students should use test results to make claims about how their toy box organizer met the above criteria.

Signed,

_____

TALIA'S TOY BOX COMPANY

Dear Students,

Thank you for all of your hard work on designing and testing the toy box organizers. I received your letters, pictures, maps, and test results. I really like all of the different prototypes you designed. I look forward to sharing these designs with my customers. Good job, engineers!

The toy box organizer will make the Travel with Me Toy Box neat and organized. It will help kids find their toys faster and easier. This will make their parents, my customers, very happy!

Thank you for all of your help!

Sincerely,

Talia Lukas

Talia Lukas
CEO, Talia's Toy Box Company

1234 Toy Lane West Lafayette, IN 47906 Phone: 765-567-8910
Email: Talia@taliastoyboxco.com www.TaliasToyBoxCo.com

Delete | Reply | Reply All | Forward | Move | Related | Follow Up

From: Talia@taliastoyboxco.com
To: StudentEngineers@gmail.com
CC:
Subject: Thank you from Talia's Toy Box Company

Dear Students,

Thank you for all of your hard work on designing and testing the toy box organizers. I received your letters, pictures, maps, and test results. I really like all of the different prototypes you designed. I look forward to sharing these designs with my customers. Good job, engineers!

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Thank you for all of your help!

Talia Lukas
CEO, Talia's Toy Box Company