A House for Chase the Dog

Second-grade students investigate material properties.

By Meghan E. Marrero, Amanda M. Gunning, and Christina Buonamano

From a young age, children encounter different materials and learn color, hardness, texture, and shape. Focusing on observable properties is an engaging way to introduce young children to matter. In this investigation, students use observations and engineering design to decide which material would make the best roof for a doghouse. We used the 5E model (BSCS and IBM 1989) to create an engaging inquiry-based activity to meet standards and make real-life connections to physical science content. Our second-grade students enjoyed the activity and came to understand how physical properties can determine how a material is used.

Material properties are an important foundational piece of physical science content. As students advance, these early connections will be built on in chemistry, Earth science, and physics. At this age, students are learning that materials are suited for different purposes because of their properties. The children should be able to analyze data related to properties and sort materials based on this analysis. Some material properties appropriate for this age group are: strength, flexibility, hardness, texture, and absorbency (NGSS Lead States 2013). Early exploration of properties and classification helps support continued engineering work in upper elementary grades (Lachapelle et al. 2012).

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Chase the dog needs a house.

Lesson Objectives

As two graduate education professors and one elementary school teacher, we have used this activity with preK and elementary students, varying the amount of support provided as was developmentally appropriate. This article describes how we implemented the activity with a group of primary students in one class period. Our students were introduced to the *Next Generation Science Standards* model of the engineering design process and given different materials to test to determine the best solution for creating the roof of a doghouse to withstand rain. We chose to model activities with students first, giving them the opportunity to experience the appropriate science and engineering practices but still allowing us to finish the activity within one class period.

In the end, students were able to (1) Draw on personal experience and prior knowledge by explaining that roofs function to protect humans and pets from the elements, particularly precipitation; (2) Compare how different materials stand up against rain; (3) Use observable data to compare roof materials; and (4) Decide which roof material is best, based on evidence from their engineering investigation.

Engage

Where do animals and people go when it rains? We used this question as a starting point for discussion leading into the activity. In our class, students said they went inside their homes, cars, and inside the school. From there, we inquired why is it important to go to those places (to stay dry) and how these places help you (or animals) stay dry in the rain. Children quickly realized the roofs of all of these places keep the rain out.

Next, we showed the class a picture of a classmate's new dog, and asked whether any students have a dog at home and whether their dogs like to be outside. We explained to students that we wanted their help, and read the following scenario:

Chase the dog loves being outside. Although he has a family and a warm, dry house, he prefers to hang out in the backyard, no matter the weather. Chase has two loving kids in his house, and they are concerned for their pet. The kids have decided that the best way to keep Chase both happy and safe is to design the perfect doghouse to protect him from the elements. Your task is to begin testing roof designs and to decide—what is the best material to use for the roof of Chase's doghouse to keep him dry in the rain?

We also introduced students to an example of engineering design process and shared the engineering design process graphic from the *NGSS* (Figure 1), discussing each step of the process and explaining that engineers design, build, and test solutions to problems. We asked whether any students know an engineer and what engineers do. Discussing engineering generally helps explain the integral role engineers play in our designed world.

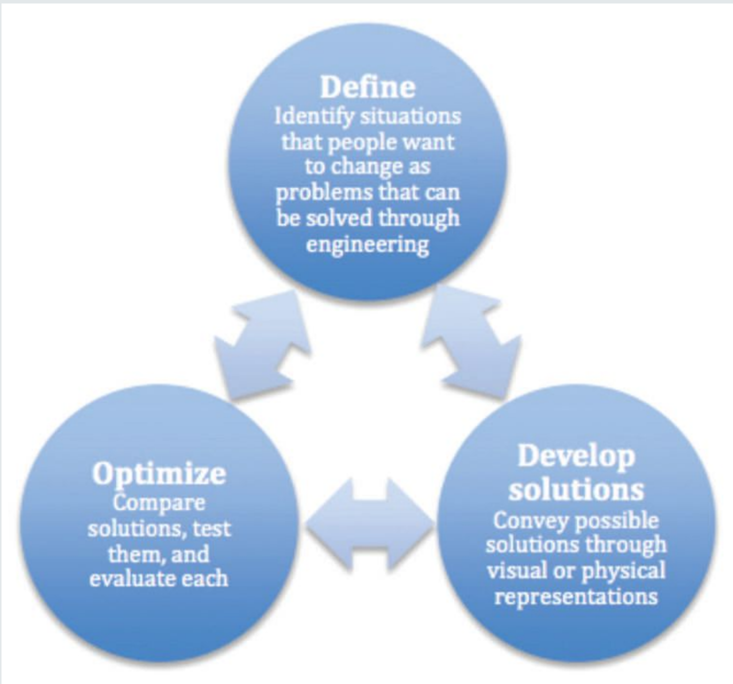
Explore

As with all hands-on activities with young children, this activity should be modeled before materials are distributed to students. It is important to always discuss safety with students before beginning any hands-on exploration. Be sure all milk cartons are cleaned out and prepared for student work. Start by showing the milk carton "doghouse" base and explaining it is a *model*. We introduce the idea that scientists use models all the time to learn more about what is being studied. For example, you may talk about past activities you have done with students, such as modeling friction by driving toy cars over different "roadways" (e.g., rug vs. tile). Explain that engineers use models to test their designs. For this activity, instead of testing materials on a big doghouse in someone's backyard, we use the milk carton base. Ask students questions such as: *Why do you think it is a good idea to use a model?* Show the different roof materials (Figure 2, p. 78) to the class and discuss: *What might make a good roof material? What might we observe happen to a poor roof in the "rain" (water spray)?* Record discussion comments on the board for visual learners.

Model for students how to lay the squares of material on top of the "house" one at a time and use the rubber band to secure it, if needed,

FIGURE 1.

The *Next Generation Science Standards* engineering design process for young learners.



by stretching it around the mouth of the milk carton. Note that students may choose to design their roofs in different ways; these designs can be a basis for discussion later (e.g., some students may choose to crease the materials to make a peaked roof). Once the testing process has been modeled for students, show the Predict Observe Explain (POE) chart (see NSTA Connection). Explain that for each material they test, they will need to predict what will happen when they sprinkle water on it before they actually do so. It is a good idea to model what is expected and have the students reiterate the directions before they begin. We also found it useful to have students make predictions for each of their roof materials before we handed out any water. If working in groups is new to your students, be sure to model how to work collaboratively and to continue to discuss, write, and/or illustrate thoughts until they are told to stop.

Students should be divided into groups of three, if possible. We created our groups by considering the level of each child's cognitive stage of development. We addressed the needs of students who are at an introductory level as well as those who are ready for more in-depth, higher- level thinking. This allowed for varied levels of scaffolding to take place during the lesson. Tiering lessons and differentiation occurs on a daily basis, so children were unaware of the grouping methods while working together at their level of readiness. Higher-performing groups were given roof materials that had similar properties, or were all generally good roofs (e.g., cardboard, shower curtain, foil). In this way, higher-performing groups would have to distinguish observations and decide which material was best based on its properties. Groups of lower-performing students were given roofing material with observable differences, such as construction paper, cloth, and shower curtain. You may choose also to differentiate groups based on learning styles or any other way that you feel will benefit your students, while providing them with the same material to complete the lesson.

Once students had their materials (but not any water), they examined the possible roofs and listed each under the first column on their group POE chart (Figure 3). Students then predicted what they thought would happen to each when it would rain on each material and recorded their predictions in the second column. After much anticipation, students were given the sprayers and cups with water and droppers. Students should be reminded not to spray one another. Also be mindful of

FIGURE 2.

Materials for each group of three students.

- Precut quart-size milk carton
- Cups
- Water
- Spray bottle filled with water
- Eye droppers (1–3 per group)
- Thin, large rubber bands
- Aluminum baking trays

All cut to 10" square:
- Wax paper
- Poster paper
- Cardboard
- Aluminum foil
- Construction paper
- Cloth (e.g., old T-shirts)
- Shower curtain

Other:
- Sharp scissors (for adult use to cut cardboard and milk cartons)
- Children's safety scissors (to cut other materials, if desired)

Preparation

For each of the materials, cut a square for each group that is approximately 10 inches by 10 inches. Students in grade 2 can measure and cut materials on their own, as an additional learning activity incorporating math. Care should be used if students are cutting materials themselves, and only adults should be cutting the thicker materials, such as cardboard or the milk cartons.

Save enough empty, quart-sized milk cartons for the class and cut each milk carton all the way around, about 3 inches from the bottom, This makes the bottom of a "house."

Create a setup for each group in the baking trays, where you place in each: a cut off milk carton, eye dropper, cup (to be filled with water for the eye dropper), rubber band, and spray bottle.

slip hazards from wet floors. Remind students to use their eyes to see the roof and their fingers to touch the roof as part of observing. They can also look inside the house. Observations should be recorded in the third column of the POE chart. Students might also consider drawing their observations.

Explain

After each observation is recorded, students should fill in the Explain column to decide whether a given material has properties that would make it a good roof and why. It is important for students to provide evidence for their assertions. After the experiment, teams of students brought their POE sheets to the rug and shared their findings, discussing which material they thought was the best for the doghouse roof and their supporting evidence. The *NGSS* remind us that we must ask students to explain the solutions they have developed, "Asking students to demonstrate their own explanations . . . [of] models they have developed, engages them in an essential part of the process by which conceptual change can occur" (NRC 2012, p. 68). We helped students make connections between the structure and properties of the materials (e.g., the wax paper had a coating that caused water to bead up). We used questions similar to those in Figure 4, page 80, to spark discussion. We included sample student responses taken from their POE sheets' Explain column.

Stress to students that they are using scientific observations (i.e., data) to support their ideas. Scientists and engineers must rely on

A student explains how paper would not make a good roof.

FIGURE 3.

Sample POE chart with students' predictions, observations, and explanations.

	Prediction	Observation	Explanation
Roof Material 1: papr	get wet Dissolve it will stay strat	dript through chase will get wet	chase will get wet rain will silk through
Roof Material 2: plastic	huas stayd Dry	water made a puddle stayd out and chase	The water rolld off
Roof Material 3: materal cloth	it will go through	It whent through Chase will get wet	Chae will get wet The water drips though

data to make decisions, in this case, about which type of roof would be the best. Material properties of the roofs dictate their performance (e.g., smooth, nonporous materials, like the shower curtain and foil, will allow water to roll off). Other materials that are porous, such as the cloth, will get wet and eventually may allow water to drip through. Direct the teams to share their findings. Because they each tested different materials, ask them how they can make a decision about the best roof material. Explain that there is not necessarily one right answer, but that students should use evidence, which is their observational data, to support the solution they designed. This connects directly with the *NGSS* science and engineering practice of Constructing Explanations (for science) and Designing Solutions (for engineering).

Ask students why some materials worked better than others for this purpose. Students should be able to explain that different materials have different characteristics, or properties. Some of the materials, for example, have the property of absorbing or repelling water. We asked students, "What are some properties that are important for designing a roof? Answers included, "Being strong; Being firm; Preventing water from going through." Discuss the students' findings in light of the concept of properties. Record the properties that students share and explain properties are a way of describing a material or matter, in general. Students should come to understand that different material properties can make that material better suited for different functions, highlighting the *NGSS* crosscutting concept of Structure and Function.

Through questioning, help students to understand that the properties of different materials make them suitable for different purposes. Ask, "Why is cloth better than a shower curtain for a T-shirt?" *The fabric is much more "breathable" and comfortable.* If applicable, the discussion may also shift to the shapes in which students designed their roofs. Some student teams may have designed their roof to be more sloped, whereas other roofs were flat. Use these differences as an opportunity to further discuss structure and function, asking students to share how effective the different shapes were at keeping the rain out of the house and ensuring the roof is strong.

FIGURE 4.

Sample teacher questions and student answers.

Teacher Prompt	Sample Student Responses
Which material did the best job holding out the rain? Why?	*Students discussed how the curtain was best because the water slid off of it, and the foil was good because the water didn't get in the house.*
How did you know if the material will make an effective roof?	*"Chase will get wet. Rain will sink through." "When the wax paper got wet my finger went through." "Paper ripped. It is not a good roof"*
What happened when you used a piece of shower curtain?	*"The water stayed on the roof and did not go in there." "The water rolled off."*
How did the cloth perform in the experiment?	*"Chase will get wet the water drips though."*
How well did your predictions match up with your observations? Were you surprised by anything you found?	*Students in one group discussed that they noticed the construction paper worked as long as it didn't rain hard. When it rained hard, it got soft and you could make a hole in it, which prompted us to discuss the importance of the roof being able to sustain several rainstorms.*

Elaborate

Have students describe the materials from which houses or buildings are made in your area. Ask students whether they have traveled to different places and whether the homes looked similar or different. Ask whether they think that houses are made from the same materials everywhere and why. Show students some photographs of different types of homes (e.g., a mud hut in Africa, Adobe house in the American Southwest, yurt in Mongolia). Ask students to share ideas as to why they think the homes are made of different materials (i.e., ask them to consider the materials available in different areas and also different climates). *What kinds of roofs do these houses have? Why are these features important for these roofs?*

To further explore material properties, see Internet Resources for a website to test metal, glass, rubber, paper, and fabric for transparency, flexibility, strength, and whether they are waterproof. The site reads the text out loud if the speaker icon is clicked, which is a great support for ELL students. It also features a quiz students may try. This application can be explored as a whole class or by individual or small groups of students, but the teacher should model it first.

Evaluate and Extensions

Opportunities for formative assessments are present throughout this activity. Begin in the whole-class portion of the lesson by drawing on students' prior understandings of shelter and its function. While working on the activity, observe how student teams are testing the materials, and note student conversation and the observations and explanations cited on their worksheets to assess how they use engineering practices. During the class discussion, each team should share ideas and support them with evidence, allowing the teacher to assess how students are constructing their explanations and designing solutions.

As a homework assignment and extension of the activity, ask students to think about the materials they tested in class. Using those materials, students could design a coat for Chase to wear when he is in the yard, in case of rain. Students should find a design team partner at home—a parent, sibling, or other caregiver—to help with the assignment. Students should explain the roof testing that was done in school and about how the different materials performed in the rain. Using this information, they should determine which material or materials would be the best to create a coat for Chase. Students should specifically include the material properties of the items

Students prepare to test a shower curtain roof.

used in their design and why they were chosen (see NSTA Connection). ■

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Acknowledgment

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References

BSCS and IBM. 1989. *New designs for elementary science and health: A cooperative project between Biological Sciences Curriculum Study (BSCS) and International Business Machines (IBM)*. Dubuque, IA: Kendall Hunt.

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

2-PS1-1 Matter and Its Interactions

www.nextgenscience.org/2-ps1-1-matter-and-its-interactions

The materials/lessons/activities outlined in this article are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required.

Performance Expectation	Connections to Classroom Activity *Students:*
2-PS1-2. Analyze data obtained from testing different materials to determine which materials are best suited for an intended purpose.	• test varied materials and use observations to decide which materials are best suited as a roof to withstand rainfall.
Science and Engineering Practice	
Analyzing and Interpreting Data	• collect qualitative data in a chart as they test different materials under spray bottle "rainfall." • discuss observations with group members. • interpret data to determine whether each material was effective. • explore an online application that tests different materials and properties.
Disciplinary Core Idea	
PS1.A. Structure and Properties of Matter • Different properties are suited to different purposes.	• test materials' suitability for use as a roofing material. • discuss properties of materials observed in the activity. • observe varied home designs and discuss properties of different materials used to build them. • discuss which properties are better suited for a shower curtain or T-shirt.
Crosscutting Concept	
Structure and Function	• examine how the properties of different materials affect how they function, as they test their properties under "rainfall." • discuss why a rigid roof is important to hold up against rainfall (can be extended to snowfall).

Lachapelle, C.P., C.M. Cunningham, J. Facchiano, C. Sanderson et al. 2012. Limestone or wax? *Science and Children* 50 (4): 54–61.
NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press. *www.nextgenscience.org/next-generation-science-standards*
National Research Council. 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academies Press.

Internet Resource

Characteristics of Materials
www.bbc.co.uk/schools/scienceclips/ages/7_8/characteristics_materials_fs.shtml

NSTA Connection

For a homework rubric and worksheet, as well as blank POE worksheet, visit *www.nsta.org/SC1601*.

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

K-2-ETS1-3. Engineering Design

www.nextgenscience.org/k-2-ets1-3-engineering-design

The materials/lessons/activities outlined in this article are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required.

Performance Expectation	Connections to Classroom Activity *Students:*
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	• compare different roof materials in terms of how they perform under model rainfall, and analyze the strengths and weaknesses of each.
Science and Engineering Practice	
Constructing Explanations and Designing Solutions	• explain why roofs are important and what features are needed to make a good roof. • design solutions to the problem of building the best roof for a doghouse to withstand rainfall.
Disciplinary Core Idea	
ETS1.C: Optimizing the Design Solution • Because there is always more than one possible solution to a problem, it is useful to compare and test designs	• test different materials and compare how they stand up to a model of rainfall. • discuss the different roofs that were tested and identify the best-performing roofs and the properties they had in common.
Crosscutting Concept	
Structure and Function	• compare materials and explain what make them suited or not suited for use as a roof material.