Overview

This classroom manual is designed to assist teachers and parents in the planning, implementation, and management of instruction for the Properties Matter e-book. It lays out learning goals for each topic, shares likely student misconceptions and how to address them, and highlights where students explicitly practice science and use crosscutting concepts to support their learning. It also provides investigations that connect readings and interactives in the book with students’ world.

Properties Matter and the classroom manual were carefully crafted to provide opportunities for the implementation of additional teaching strategies that the author has found to be very useful when teaching elementary science. Teachers often ask how they can use cooperative grouping with their students and how to show students what working cooperatively looks like. This e-book provides both opportunities. The main characters, Bobby and Carmen, work cooperatively as a team throughout the story. They have found themselves short on time and materials, but by working cooperatively, as scientists, they are able to successfully complete their tasks. This story theme provides students with many opportunities to evaluate how they can work together cooperatively to accomplish their tasks. Within this guide, teachers will find student job cards for cooperative grouping. You will notice that the job cards can be easily used with several subjects such as science, literature, and math. The author suggests adapting the jobs to meet the needs of your students.

Another area of concern for many teachers is vocabulary and language development. Teachers have found that children seem to be using more filler words or substitution words, calling an object that thing or it, for example, rather than using correct vocabulary. The importance of incorporating vocabulary repetition with multiple exposures into science lessons is often a major concern of teachers. Properties Matter exposes students to correct vocabulary in context, including vocabulary of solid shapes and their physical properties. The Properties Matter classroom manual provides suggestions for student discussion and vocabulary development. These opportunities, while helping all students, are very important to English language learners.
On this page Bobby and Carmen delve deeper into the design process. Their problems are becoming more complex! What are the criteria that Bobby and Carmen will need to consider in order to create a successful design? What materials do they have to use? What are the constraints or limitations that they must consider? Bobby and Carmen need to carefully consider these questions in order to make a successful design and locate the most suitable materials. Will they be able to be successful at researching possible solutions to their questions?

This step provides teachers with another opportunity to teach cause and effect. Direct students to consider various scenarios. What if they make this choice of materials? What is the cause and what will be the effect? What constraints will they face with their design based on their materials choices? Help students to understand the usefulness of asking these questions. Use a T-chart or flowchart to record responses.

Think Like a Scientist and Engineer

How are Bobby and Carmen thinking like scientists and engineers? Record the science skills on their list. Bobby and Carmen are investigating the materials on the shelves. As students observe the available materials on the shelves, they are asking questions related to their problem. Asking and responding to their own questions allows them to determine criteria for a successful design: what would work and what wouldn’t.
End-of-Topic Engineering Process Practice: Defining the Problem and Researching Possible Solutions

Note: This will be an ongoing activity that parallels the engineering design process as presented in this e-book.

Divide students into groups. Provide students with materials commonly found in a second grade classroom (e.g., straws, string, cardboard, etc.). These can be the same materials you showed your students on page 4 when you asked them to brainstorm ideas. Explain that they will be using the materials to build something to share with the class. Ask children to define the problem they are going to solve and then to research possible solutions.

Note: You may want to give students a more specific challenge. This NSTA web page has suggestions for activities: http://ngss.nsta.org/DisplayStandard.aspx?view=pe&tid=60.

Job cards for cooperative group activities:

Make enough copies of the job cards below for the number of groups you are working with. These cards can be laminated. Punch two holes in the top of each card. Put a long piece of yarn through the holes. Distribute the cards to each person in the group. Students can wear the cards as they work. Make sure the cards are worn safely. If you have any safety concerns, place cards in front of students instead of having them wear them. You can adapt the jobs to fit the needs of your students.

**Job Cards**

<table>
<thead>
<tr>
<th>Leader</th>
<th>Recorder</th>
<th>Materials Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leader leads the group; helps group focus on the task and makes sure everyone stays on topic and follows class rules.</td>
<td>Recorder writes down group ideas and important notes.</td>
<td>Materials manager gets and organizes materials.</td>
</tr>
<tr>
<td>Presenter</td>
<td>Checker</td>
<td>Math Leader</td>
</tr>
<tr>
<td>Presenter organizes the presentation that the team will use to tell the rest of the class about the project.</td>
<td>Checker checks the work of the group.</td>
<td>Math leader uses math tools; leads team in solving math problems.</td>
</tr>
</tbody>
</table>

Provide the recorder in the group with paper.

Students should brainstorm several project ideas.

Ask students to decide which project their group will make.
Bobby and Carmen divide their jobs as they prepare to test different materials. They need measurement tools and the building materials to test. Why does Carmen grab a plastic car along with the measurement tools? Students should recognize that if the characters are building a track for a car, they need to test how a car would move on the track. What kind of measurement tools do you think Carmen might be getting? How might the children be planning to use the measurement tools? Possible answers include any appropriate measurement tool (ruler, yardstick, etc.) and explanations for why they would use those.

Take this opportunity to assess what sort of tools students identify as measuring tools. Record their ideas on a table like the one below. Periodically refer back to this table and see if students have any new tools they want to add. On the next page, two tools are introduced.

Measuring tools table:

<table>
<thead>
<tr>
<th>Tool</th>
<th>Job/What it Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>
Bobby and Carmen find cardboard, sandpaper, foil, and some plastic blocks on the materials shelf. They also have a ruler and a timer for testing the materials. At this point, students should wonder if the characters have enough of the right kind of materials to complete their project. This is a project constraint. One of the parts of engineering design is identifying constraints in a project, or limitations in what they can do. We have already identified one constraint earlier in the e-book (time). The characters’ project constraints are time and materials.

Take this opportunity to build on the earlier tools table. Two tools are introduced on this page. Before telling students what the tools mentioned on the page do, ask them to describe how they have used these tools before. Through doing this, they are using prior experience as evidence for how to use scientific measurement tools. Record their answers in the table. Are there any other tools they want to add? How can they confirm their responses are correct?

<table>
<thead>
<tr>
<th>Tool</th>
<th>Job/What it Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruler</td>
<td>distance, inches, centimeters, length</td>
</tr>
<tr>
<td>Timer</td>
<td>time, seconds, minutes</td>
</tr>
</tbody>
</table>

Continue a discussion about materials. The characters have chosen several different materials to test. What possible problems do you foresee the children having with their material choices? Ask students to make a prediction about different properties these materials have. What properties are necessary to make the best track?
Bobby and Carmen are ready to build their track but they find out they do not have enough materials. Ask students how Bobby and Carmen decide to solve their problem. (They decide to redesign their track. They consider using blocks to complete the track. They are repeating steps in the design process.)

In the list of engineering design steps, step 5 is highlighted (test structure) but not step 6. Ask your students why they believe step 5 is highlighted on this page. Look for them to understand that in order to know they needed to redesign, Bobby and Carmen needed to first test the structure. When the test fails because the structure isn’t complete due to not having enough materials, they know a redesign is required.

Students are asked in the e-book how Bobby and Carmen could use additional materials they find to redesign their track. What are some ways that the track could be redesigned?
Topic 4

Repeating the Process—Designing, Building, and Testing Cars

This topic reiterates to students that the design steps can be repeated, whether it is because a redesign is necessary (as shown in the previous topic) or because new constraints or a new project have begun in association with what they were working on. In Topics 1 and 2, Bobby and Carmen decide to solve their problem by building a track. Now they need cars. They selected their materials for the track and now need to design, test, and select materials for their cars. Students will be comparing different solutions to solve problems and using tools to design, test, and build a device that solves a specific problem. Students learn that using the design process is open-ended and not linear or cyclical.

By the end of the topic, students will be able to:

• describe a problem that can be addressed by the development of a new product;
• make observations in the classroom or community to use as evidence of a design problem that can be solved;
• identify constraints of a design problem and how it will affect the process and product;
• plan and carry out an engineering design using limited materials and time;
• work collaboratively to build a design with a shape and stability related to its function(s);
• analyze data from tests to evaluate if different materials work as intended as possible solutions to a problem; and
• communicate the suitability of different material choices as different solutions to a problem, citing evidence.
Bobby and Carmen are going to sort the blocks. On this page, the term solid shapes is introduced to represent three-dimensional shapes. Students should begin thinking about how a two-dimensional design with plane shapes will translate into a three-dimensional object.

Possible discussion prompts:

- How will sorting the blocks help them?
- What are the physical properties of the blocks?
- Bobby and Carmen sort the blocks by identifying their shapes.
  - What other ways could they sort the blocks?
  - Would these other methods for sorting the blocks be beneficial?
  - What situations would make the other sorting methods better?

How are Bobby and Carmen thinking like scientists and engineers? Continue listing science skills used by Bobby and Carmen.

Bobby and Carmen are categorizing items based off of similar properties. They are observing patterns in the different materials and analyzing where they best fit.
Bobby and Carmen watch a video about cubed wheels. Carmen learns that she is not the first person to create a vehicle with cubes for wheels. She has two choices: change the wheels on her car or change the material of the track. What should they do?

Should Bobby and Carmen redesign and rebuild their track? Have students write out the pros and cons of redesigning and rebuilding the track and record their responses in a T chart. What problems might arise if they switch the flat cardboard with the corrugated cardboard? Some responses could include:

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carmen’s car will roll</td>
<td>Bobby’s car will not roll</td>
</tr>
<tr>
<td>Will require more time to redesign and rebuild and they may not finish their project</td>
<td></td>
</tr>
</tbody>
</table>

Have your students then make a decision about what track material they should use based off the evidence in their list. This kind of process is all part of the engineering process. Scientists and engineers have to evaluate possible solutions and their merits as they work toward a final product in the same way that your students just did.

You can then have students repeat this activity to help Carmen make a decision about whether she should redesign and rebuild her car.