Grade 3: What are Things in My World Make Of? How Much is There?

Dear Workshop Leader

These materials will help you get ready to lead an Implementation Workshop for the Grade 3 Inquiry curriculum, What are Things in My World Make Of? How Much is There? This curriculum is a carefully crafted, research-based progression about Matter for grades 3-5. The curriculum includes a detailed Teacher's Guide and additional resources for teachers. Why hold an implementation workshop? A teacher who is about to use the Inquiry curriculum for the first time has a lot to think about and will have many questions:

- big picture questions about the key science ideas,
- logistical questions about managing materials,
- pedagogical questions about how students work with data or learn to reason scientifically.

This workshop

- helps teachers answer some of these questions.
- illustrates the “architecture” of The Inquiry Project website.
- facilitates teachers’ own firsthand experience of some of the key investigations, using materials from the kit.
- models ways to answer questions, work with data, and lead discussions.
- highlights resources available for teachers when they want to know more about specific science content or children’s ideas about these same topics.

In our experience, teachers like to be active explorers. They like experiencing some of the investigations firsthand. They like the combination of the theoretical and the practical information and the tight connection between the workshop content and what they are about to teach.

The workshop requires 6-hours. The time could be organized as a full day workshop, two three-hour, or three two-hour workshops.

You can use these materials as is or modify them to meet the needs of your group of participants. It is essential that you become very familiar with the curriculum, the organization and contents of the Teacher’s Guide, The Child and the Scientist essays, and the Concept Cartoons.

Be sure to try the firsthand activities yourself before you ask participants to experience them in the workshop.

As you begin planning, print out (in color if possible) this Grade 3 Implementation Workshop Leader’s Guide (pdf)
1 Workshop Goals
By the end of the workshop, participants will

1. be familiar with the conceptual flow of The Inquiry Project curriculum Grades 3-5 and see where the Grade 3 curriculum fits in the progression
2. know their way around The Inquiry Project curriculum website, the Grade 3 curriculum, and resources for teachers
3. have firsthand experience with some key science investigations
4. know how to find resources they can use to deepen their understanding of the science content of the curriculum and children’s ideas about these topics

2 Before the Workshop
This workshop leader guide is based on the assumption that you are familiar with The Inquiry Project materials and have specific knowledge and understanding of the investigations in the Grade 3, Things in My World Make Of? How Much is There? curriculum. If the curriculum is new to you, it is critical that you read the Teacher’s Guide carefully, try the firsthand investigations that are part of the workshop yourself, review the video classroom and Scientist Cases, and follow links that are provided in these workshop notes.

1. Workshop space. Arrange for a workshop space where participants can work in groups around a table or cluster of desks and everyone can see a screen or SMARTBoard.
2. Lap top or tablet for everyone. Check to be sure everyone – you and participants – can connect to the Internet and there’s a screen or SMARTBoard where you can project The Inquiry Project website. You will want to encourage participants to bring a lap top or tablet to the workshop and to follow along as you guide them through the curriculum and professional development resources on the website.
3. Materials. Gather and organize materials (see Implementation Workshops, Grade 3, Master Workshop Materials List at the end of this document). Materials are also listed where they are called for in the workshop.

Provide a scale and set of materials for every 2, 3, or 4 participants.
4. Agenda and Goals. Post an agenda and a list of workshops goals that will be visible throughout the workshop. See Workshop Goals above. Your agenda will depend on how you organize the 6 hours, e.g., full-day workshop, two 3-hour or three 2-hour workshops.
5. Data tables. Prepare group data tables and charts participants will use to record group data during the workshop.
6. Handouts. Print out the Grade 3 Workshop Handout packet. There are few Handouts needed for this workshop. Throughout the workshop, participants have access to the Teacher’s Guide on their lap tops or tablets that contains examples of all data tables and Notebook pages (pdfs) that they can use as models.

3 The Workshop

SET THE STAGE
Project a slide show of images from the three Inquiry Curricula (Implementation Workshops on the Home Page)

WELCOME
Tailor your welcome to your group of participants and particular setting.
Workshop leader and participants introduce themselves - briefly.
Introduce the Home Page

HANDOUTS
Working with materials for groups of 4 will model what happens in the classroom; having materials for every pair will allow more firsthand experience in a shorter amount of time.

TIP
Click Curriculum Grade 3

**SMALL GROUP ACTIVITY**

What are the core ideas and science concepts in this curriculum? (~10 min.)

Click Science Concepts Grades 3-5 (sidebar menu).

Ask participants to use a copy of this chart found in the Handout packet.

And take 5 minutes to discuss the question below:

"What can we expect our students to understand about the nature of matter as they wrap up Grade 3? What are Things in my World Made of? How Much is There? How are these ideas developed in Grades 4 and 5?"

Take a few minutes to find out what participants noticed and what questions they have.
Emphasize that students learn about matter through a coherent sequence of investigations across the three grades and learn to use the eight practices described in *A Framework for K-8 Science Education* (2012)

1. Asking questions
2. Designing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

### 4 Overview of the Grade 3 Curriculum

Explain that you’ll now look more closely at the Grade 3 curriculum.

Click **Overview** on the sidebar menu and make the points below.

This curriculum is called *What are Things in My World Make Of? How Much is There?* There are 17 Investigations grouped in 4 clusters.

These investigations provide evidence to support students’ understanding of five very important science ideas about matter. The first two are about weight: the weight of solids and/or liquids can be compared using a digital scale and can be represented on a weight line or data table; weight is conserved during crushing and reshaping.

The next big ideas are about volume: liquid and solid volumes can be measured in cubic centimeters; when immersed, a solid displaces a liquid volume equal to the solid volume.

The next idea is about material: the relationship between weight and volume (i.e., density) is a property of solid and liquid materials.

The last idea is about matter: matter can be divided into tiny pieces, and even the tiniest pieces have weight and take up space.

### 5 Get to know the Grade 3 Website

Tell participants that The Inquiry Project includes a detailed *Teacher’s Guide* to the curriculum plus a rich set of resources for teachers that are all closely tied to the classroom investigations. Links to resources are embedded in the online *Teacher’s Guide* and also can be accessed from the sidebar menu on the left. These materials can be used online or printed out.

Explain that to get started becoming familiar with the navigation and resources of the Grade 3 website, you’ll take them on a quick tour of what’s they’ll find when they use the sidebar menu.

Encourage participants to follow the tour on their own laptops or tablets and say you hope they’ll explore the web site throughout the workshop.

Play the movie. You can pause the video tour at any point.

Click **PD FOR TEACHERS/Implementation Workshops/Grade 3 Workshop/Sidebar Tour**
I: To the Workshop Leader

Introducing Investigating Materials

This workshop looks at the Inquiry curriculum through two lenses: the overarching organization and goals or big picture on one hand, and step-by-step details on the other. Teachers need both perspectives, (1) how learning experiences connect and contribute to understanding core science ideas, concepts, and scientific practices and (2) the specifics of how to carry out investigations.

Teachers may be surprised to find that it’s a challenge for students to differentiate objects from the materials they are made of. By the end of the first two investigations, students are able to make the distinction and are ready to turn to properties of materials. Here’s where a set of eight cubes - all the same size but each made of a different material - comes in handy. Through sorting and ordering the cubes, students become familiar with the concept of “property,” including the observation that although they are identical in size, each cube weighs more or less than others. The idea that same-sized samples of different materials have different weights will come up again as students continue to learn about matter.

As you plan the ideas you’ll emphasize in each Section, look for a chart, How Investigations Reflect the Science Framework, that follows a description of Materials and Preparation for this part of the workshop. Here you’ll find a concise summary of ideas, scientific practices, and crosscutting concepts to emphasize as you lead participants through the first five investigations.

Overview of Grade 3 Curriculum

“What are Things in My World Made of?”
“How Much is There?”

The third grade curriculum has four strands that help set the foundation for a learning progression in the nature of matter. The first strand, Investigating Materials, helps students distinguish between objects and materials. Students build their understanding that objects in their daily lives are made of many different types of materials with different properties. The second strand, Investigating Weight, focuses on weight as a property of matter. Students make the transition from felt weight, perceived with their hands, to measured weight using a pan balance. The third strand, Investigating Standard Measures, has students share their measurements of weight with each other and introduces the need for a standard unit of measurement. The fourth strand, Investigating Volume, introduces volume as another important property of matter.

Embedded within these strands are the development of representations (most significantly, a number line used to represent weight) as well as scientific models and explanations through discussions, notebooks, and the use of concept cartoons.
II. Section I: Investigating Materials, Investigations 1-5

The Grade 3 curriculum has four groups of investigations or sections; each section opens with an overview page containing important information for teachers. You are looking at the opening page for 1. Investigating Materials.

Before participants dive into the investigations in each section (Part III), you’ll want to describe the elements of the opening page. An annotated image similar to the one below is included in Part II of each section.

A summary of the major ideas and activities in this set of investigations of earth materials.

5 investigations that focus on the distinction between objects and materials, properties of materials, and finally, how the properties of materials that objects are made of support the function of these objects.

The Child and the Scientist
This link takes you to a pair of essays. Here you can find out how students’ ideas about materials differ from scientists’ so you can help your students use evidence they collect to move closer to a scientific understanding.

Concept Cartoon
This link takes you to a cartoon style assessment item designed to probe students’ beginning understanding that same-sized samples of different materials will have different weights, not because one is hollow or another filled with rocks, but because the material itself is lighter or heavier for the size of the sample. This idea is a precursor to understanding the property called density.
Materials and Preparation for this part of the Workshop

A critical part of the workshop is the opportunity for participants to experience student investigations firsthand and raise questions about materials management and logistics. In addition to a materials list for each section of the curriculum, you’ll find a Master Materials List at the end of this document.

Investigating Materials 1

For each group of 2-4 participants and one for the Workshop Leader

- piece of cardboard, approx 2”x2”
- plastic-covered copper wire, approx 6” long
- bare copper wire; approx 6” long
- piece of cotton cloth fabric, approx 2”x2”
- wooden spoon (ice cream type)
- metal spoon
- plastic spoon
- metal key
- steel bolt
- 3-oz paper cup
- rubber eraser
- plastic counting bear
- steel washer
- wooden coffee stirrer
- pencil

Investigating Materials 2

- 1 plastic spoon for class discussion

For each participant:

- 1 personal object selected by participant

Investigating Materials 3

- Prepare a class table to record students’ findings; an example is shown in Step 3.

For each group of 3-4:

- A full set of 8 material cubes, each cube labeled with the name of its material:
  - pine
  - oak
  - steel
  - copper
  - aluminum
  - nylon
  - PVC
  - acrylic
Investigating Materials 4
For the workshop leader

- Gather 10–12 common classroom objects
- 2 cubes that have been cut in half (kit)

For each group of 3-4:

- 1 set of the material cubes

Investigating Materials 5
For each participant:

- A pencil (the object participants will draw)
- A lead pencil and colored pencils to draw with

Handout #1 My Observations of Objects and Materials (Notebook page)

Section 1 Investigating Material: How Investigations 1-5 reflect the Science Framework

<table>
<thead>
<tr>
<th>Component Ideas about Matter and Its Interactions</th>
<th>Everyday objects are made of different kinds of materials. Each material has characteristic properties. The properties of each material work to support the function of the objects made of these materials.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific Practices</td>
<td>Asking questions and defining problems: students ask what is same the same and different about eight materials. They consider materials in terms of properties that make them useful for making everyday objects that do or do not work well.</td>
</tr>
<tr>
<td>Crosscutting Concepts</td>
<td>Structure and function: students learn how to distinguish materials from the objects that they make up and how the properties of a material support its function in an object.</td>
</tr>
</tbody>
</table>
III. Investigations

In the workshop, participants will experience some – but not all – of the investigations in this section firsthand. As you begin their first experience, emphasize how important it is for teachers to actually try out materials and activities before they teach a lesson.

Click 1. Materials

A. Investigating Materials 1. What are things in my world made of?

The purpose of this activity is to learn to distinguish between an object and the materials it is made of.

Click 1. Materials, Investigation 1

Point out that each investigation begins with a Plan page. Briefly explain the information on each Plan page.

• A snapshot of the student experience, including this sentence, “By the end of this investigation students will...” and a pithy description of what students will understand and be able to do at the end of the lesson.

• The Learning goals for this investigation

• Sequence of experiences and time allotted for each

• Materials and Preparation for the class and each group of 4 students

• A formative assessment in some, but not all, investigations
1. Experience the sorting activity firsthand

a. Distribute the plate of objects (listed in Materials and Preparation) and ask participants to work in groups of 2-3.

b. Point out that the title of each lesson (called an investigation) is also the investigation question. Asking questions is a fundamental scientific practice and the investigation question organizes each lesson or learning experience.

Scroll to 1. Ask and pose the investigation question (What are things in my world made of?) and explain that participants – and their students – will collect data to answer this question.

c. Explain that the challenge is to sort the objects on their trays according to their material properties:
   - put things together that are made of the same material or “stuff”
   - make as many groups as you need
   - give each group a name
   - make a drawing that shows the name of each group and the items in it.

Display the Notebook page for participants to use as a sample.

2. Discuss the data

a. Explain that every investigation has three parts (1) ask the investigation question, (2) an exploration or data collection activity such as the sorting challenge they just experienced, and (3) a make meaning discussion.

b. Highlight the importance of discussions. Students make meaning or make sense of their work in science largely through discussion or talk. Discussions are neither optional nor add-ons to a lesson, they are essential for learning.

c. Explain that during Discussions, student sit in a circle, either on the floor or rug or arranged in their chairs so that everyone is facing everyone else and the teacher is part of the circle. They have their Notebooks handy. Ask participants to arrange themselves so they can see everyone (no one is looking at anyone’s back!)

Use this investigation to describe how the Teacher’s Guide helps teachers plan for and lead discussions.

Click 3. Make Meaning

An essential part of each investigation is time to “make meaning” through discussion (talk) of the activities students experience. Explain that the Teacher’s Guide provides support for teachers as they plan these discussions, including

- Purpose for the discussion
- A focus question related to the goals of the investigation and designed to engage students in the discussion. It takes time to craft a productive question focused on the learning goal. The Teacher’s Guide provides focus questions and suggested follow-up questions for make meaning discussions.
- Other information relevant to specific content

d. Lead a short discussion.

Ask participants to scroll to 3. Make Meaning and find the purpose of this discussion. The purpose is for students to use data to

- connect the investigation question and their data.
- reason about why there is variation in the groupings.
- make statements (claims) about the materials that objects from the classroom (things in my world) are made of and to describe the supporting evidence.

Have a collection of objects handy, e.g., a collection of the objects participants sorted, and lead off with the discussion question from the curriculum.
Ask the focus question:

**The investigation question is What are things in my world made of?**

**Based on our work with an identical set of objects, how would we answer this question?**

Ask a team to show how they grouped the objects and how they named each group (metal, plastic, rubber, etc.) Ask if there were different ways to group.

Keep an eye out for how participants place objects made of more than one material (pencil, covered wire) and note that there is more than one solution to this challenge – what’s important is that participants (and their students) are able to justify the placement in terms of the materials the object is made of.

Tell participants that the next step is to make a list of properties of metals, plastics, and wood using the question **How do you know something is a metal?** There is an example of a list from a 3rd grade classroom in the Teacher’s Guide, 3. Make Meaning.

e. Remind participants of the learning goals (scroll back to the Plan section and Learning Goals) and ask them if they think students will achieve the learning goals through the sorting activity and discussion participants have just experienced.

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Learning Goals
- to distinguish between an object (e.g., a key) and the material it is made of (e.g., metal)
- to understand that some objects (e.g., spoons) can be made of different materials (e.g., wood, metal, and plastic) and that some objects are made of more than one material (e.g., pencils)
- to observe and record details
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Explain that the last step in this investigation is part 4. Find a personal object. Each child is asked to find a small object at home, something that fits into a pocket, that they can bring to school, and leave there, for use during the study. Alternatively, a teacher can provide a set of objects for students to use. These objects will help students apply their learning in investigations that follow.

## B. Investigating Materials 2, What kind of material makes an object work well?

This investigation provides students more time to learn how to distinguish between objects and the materials they are made of, only in a new – and whimsical - context.

### 1. Describe the investigation

Use this opportunity to review the organization of a typical investigation.

a. Emphasize that Plan is essential reading for teachers getting ready to teach a lesson.

b. Scroll to 1. Ask the Question. This step includes the investigation question and suggestions for how to launch the investigation.

   In this lesson the investigation question is What kind of material makes an object work well? and the teacher launches the lesson by modeling how to use a class table to describe an object and the materials that do and don’t make it work well.

Walk participants through the first row of the table (window pane).

```
<table>
<thead>
<tr>
<th>Object</th>
<th>What it is made of</th>
<th>Other materials that might work well</th>
<th>Materials that would work badly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window pane</td>
<td>Glass</td>
<td>Plastic</td>
<td>Wood</td>
</tr>
<tr>
<td>Spoon</td>
<td>Plastic</td>
<td>Metal, wood</td>
<td>Butter</td>
</tr>
<tr>
<td>(Student use)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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c. Scroll to 2. Choose and describe an object

   Explain that the student experience in this part of the lesson is exploratory in nature: students use the personal object they selected at the end of Investigation 1 and fill in the information in the row. They do the same for at least one other group member’s object.
d. Scroll to 3. Discuss the results

Reiterate that the discussion is essential so teachers need to keep an eye on the clock and make sure to stop any activity in time to gather in a circle and have 10 minutes to talk.

The purpose of this discussion is to heighten students’ awareness of relationships between a material, its properties, and an object’s function.

e. Scroll to 4. Write a reflection.

Explain that teachers should feel free to ask students to write reflections at other times in the curriculum. There are blank pages in the Notebook and this set of reflection questions can be used at any time:

- Something interesting I learned about …
- A question I have about …
- I wonder …

C. Investigating Materials 3, How are materials the same and different?

In this investigation, a set of 8 cubes is introduced. The cubes are all the same size but are made of different materials. The cubes are used to help students compare and contrast materials in terms of their physical properties.

1. Experience the activity firsthand

   a. Ask the investigation question How are materials the same and different?

   Give each participant 2 cubes made of different materials.

   Click Plan and scroll to the Notebook page. Click the text at the bottom to enlarge the page on the screen and ask participants to make a list of properties for the material each cube is made of.
b. Bring individual observations together
Note that each participant is now quite familiar with characteristics or descriptions of two materials – they have expertise! All the “pine” experts compile a list of words that describe pine, these descriptors are recorded in a class table, and so forth, for each of the 8 materials.
Note that the Discussion focuses on similarities and differences.

2. Introducing scientific language
Point out that the term “property” is introduced at this point, after students have had experience observing and describing properties. In addition to linking a new term to a familiar object or phenomenon or experience, be explicit about what colloquialism the new term is replacing. For example, the term “material” replaces “stuff” and the term “property” replaces “description.”

D. Investigating Materials 4, How we sort cubes that are all the same size?
The purpose of the sorting activity to provide students with a greater range of properties they can use to describe materials; students also learn how to organize properties into larger categories such as color or texture.

1. Experience the investigation firsthand
   a. Explain that the materials cubes are used once again and the investigation question is How can we sort cubes that are all the same size?
   b. Distribute a set of 8 cubes to each group of 2-4 participants.
      Pose the challenge: Can you find at least 3 different ways to sort the cubes?
      Give participants 4-5 minutes to sort and record their groupings.
   c. Share the data
      Take a few minutes for participants to describe the ways they sorted.
      Point out that students typically sort (1) by weight either by ordering or grouping by heavy, medium, and light, (2) by material, (3) by property, e.g., shiny vs. dull; rough vs. smooth, etc.
   d. Making meaning
      Scroll to 4. Make Meaning.
      Explain that the focus question asks students to reason, not to come up with a “right answer.”
      These cubes are all the same size and shape but have different weights: What do you think are some possible explanations?
      Ask participants take a few minutes to discuss with a partner what they think students are likely to say, and to jot down one or two of their ideas.
      Ask people to share ideas with the group.
      Point out the ideas students typically hold.

      >>> Focus question
      These cubes are all the same size and shape but have different weights: What do you think are some possible explanations?
      ➢ The cubes are made of different materials and the materials have different weights.
      ➢ The material in metals is packed more tightly than material in wood or plastics.
      ➢ Each piece of copper weighs more than a piece of wood the same size.
      ➢ There’s more air in the wood – it doesn’t look all solid.
      ➢ The light cubes are hollow and the heavy ones filled with heavy things.

      Explain the last (hollow cube) explanation is quite common. Therefore, the kit includes a pine cube and an aluminum cube that have been cut in half.
2. Introduce a new term, “heavy for size”

Explain that at the end of this discussion, the teacher wraps up with the message that materials have properties such as color, luster, and a property the curriculum commonly refers to as “heavy – or light - for size.” This means that every cube is the same size (there is the same volume of material) but some materials are heavier for their size than others.

Alert participants to the need to include “for its size” in their descriptions of materials.

A copper cube (object) is heavier than a pine cube (object) of the same size; copper (material) is heavier for its size than pine (material). The samples must be of equal size to compare this property. After all, a large pine board will be heavier than a small piece of copper.

E. Investigating Materials 5., How do materials help us in our classrooms?

In this investigation participants (and students) consider objects, their materials, the relationship between materials, their properties, and how properties support students in their everyday lives. In this lesson you’ll also introduce observational drawing, another kind of data. Engineering concepts are embedded in the lesson.

1. Introduce observational drawing

a. Describe characteristics of an observational drawing and tell participants that they will need to model making an observational drawing for their class, using a simple object, and speaking their observations out loud and explaining what they are trying to do as they go.

Drawings should

• show what the observer saw by looking very carefully
• fill the space provided – in order to be able to include detail
• be done in pencil – easier to make changes, colored pencils can be used later
• represent the shape of the object
• include all the parts of the object
• be labeled (annotated) in pencil

b. Distribute Hand Out #1 My Observations of Objects and Materials, a pencil and colored pencils

2. Highlight structure and function, a crosscutting concept

a. Point out that the object is a pencil but it is made up of other objects: an eraser, wooden shaft covered with paint, a "lead", a metal band

b. Ask participants to complete the Notebook page by listing the materials used in the manufacture of the pencil and the “What I noticed” column.

3. Engineering connections

Point out an example of engineering concepts in this curriculum. A pencil is an engineered object. Each part of the pencil is made of a material that has been selected because its properties make the object work well. For example, graphite is very soft and a little will rub off and leave a trace as it is pulled across a piece of paper. Wood is strong, relatively light for its size, and can be easily shaped with tools – thus making it a good material for the body of the pencil.

4. Pulling it all together

Point out that as they plan this lesson, teachers need to think about how the final step can help students see how the diverse activities in these five investigations will help them better understand their world. The paragraph below from the Teacher’s Guide provides a summary.

“The idea that students depend on the properties of materials in their everyday lives is one that they can carry with them long after this class session. Whether it’s pencils, lunchboxes, bicycles, or bath tubs, students can start to make more sense of the objects in their world as they develop a greater awareness of the materials they count on every day.”
5. Remind participants of Curriculum at a Glance

Ask participants to click Curriculum at a Glance from the sidebar menu.

Explain that teachers find this a valuable resource as they get to know the Grade 3 curriculum and plan their teaching.

Provide a few minutes for participants to look at the chart.

Note that:
- this can be printed out as a pdf.
- The text provides a snapshot of the student experience.

Ask participants to click Science Concepts 3-5 on the sidebar menu.

This resource summarizes the learning progression.

Ask participants to take a few minutes to see how concepts about Material are developed further in Grades 4 and 5.

Provide a few minutes for the group to comment on what they see here and for them to ask any questions.
I. To the Workshop Leader

Introducing Investigating Weight

As you think about what ideas and practices to emphasize in this part of the workshop, one way to begin is to imagine a group of third grade students hearing that “Weight is a property of matter.” The three words, weight, property, and matter will be familiar to students from everyday conversation but the scientific meaning will not. The term “property” was introduced in the last investigation and over time, “property” will be better understood as students use it to describe objects or materials. You’ll want participants to know that weight and matter are the subjects of study not only in this unit but in the grades 4 and 5 curricula as well.

In Grade 3, we focus on weight. The four investigations in this section are built around testable questions: how good are our senses at measuring weight? If we had a pan balance would our measurements be more accurate? What units of weight do we use: if we had a bucket of paper clips, washers, counting bears could we compare weights? If we could choose just one kind of counterweight – either paper clips, washers, or counting bears – which would be best and why? As you lead participants through these investigations, emphasize the idea that their students will able to construct answers to these questions using evidence they have collected.

This learning sequence sets the stage for introducing the gram as a standard unit for measuring weight and that is the topic of the next set of investigations!

II. Section 2, Investigating Weight, Investigations 1-4

This learning sequence begins with children’s initial concept of weight as “felt weight,” moves from measuring weight with their two hands to using two pans on a balance scale. Students use the balance scale to measure weight in term of units and discover the value of using one standard unit of weight to compare the weight of objects. (See The Child and the Scientist essays)

There are 4 investigations in this sequence.

“Children's initial understanding of weight is limited, and very different from the understanding of scientists, as it is grounded in their perceptual experiences of weight.” Read these essays to learn more about what you can expect third grade children to think about weight and how these ideas can be restructured to become more similar to the ideas about weight held by scientists.

2. Investigating Weight

This series of investigations focuses on weight as a property of matter and makes the transition from felt weight (as perceived with their hands) to compared weight using a pan balance. Students are asked “How good are our senses at measuring weight?” They hold one cube in each hand, and use “felt weight” to determine which is heavier. They move from sorting objects into light and heavy towards ordering them from lightest to heaviest. However, they encounter a challenge when two cubes are close in weight, and soon realize that when the weight of two objects is similar, felt weight breaks down. In this way, the case for measurement is made.

Investigations:
1. How good are our senses at comparing the weights of the cubes?
2. What does a pan balance tell us about the weight order of the cubes?
3. How can we measure the weights of our cubes?
4. Which cube is heavier?

The Child and the Scientist

The Child: The Challenges in Learning about Weight

The Scientist: Why is Weight Important?

Concept Cartoon

The Weight Concept Cartoon is typically used as a formative assessment after Investigating Weight 4.

This Concept Cartoon is typically used after students have completed all 4 Investigating Weight lessons and serves as a formative assessment item. In some classrooms, the teacher asks students to “act out” the cartoon by reading the parts of each cartoon character. Students respond in writing to each cartoon character describing where and why they agree or disagree with the character’s ideas. Then, the class critiques each other’s responses. In some classrooms students edit their own work after discussion using a different color pen or pencil.
Materials and Preparation for this part of the workshop

*Investigating Weight 1*

For the Workshop Leader
- 3 objects that appear identical but that have clearly different weights: 3 chalk boxes containing different numbers of pieces of chalk; 3 salt shakers containing different amounts of salt
- Prepare a data table for recording the order of cubes by felt weight (step 4)

For each group of 2-3 participants:
- 1 set of cubes with the names of the materials on the cubes

*Investigating Weight 2*

For each group of 2-3 participants:
- 1 set of cubes with the names of the materials on the cubes
- 1 pan balances adjusted for accuracy

*Investigating Weight 3*

For the workshop leader:
- Prepare a data table on the SMARTBoard or chart paper where participants can record their data

For each group of 2-3 participants:
- 1 aluminum, 1 PVC, and 1 acrylic cube
- A container with a mixture of at least 25 plastic counting bears, 40 steel washers, and 85 large paper clips
- 1 pan balance

*Investigating Weight 4*

For the workshop leader:
- A plastic measure line to use as a weight line

For each group of 2-3 participants:
- 1 pan balance
- 2-3 personal objects

**How Investigating Weight reflects the Science Framework**

<table>
<thead>
<tr>
<th>Component Ideas about Matter and Its Interactions</th>
<th>The weight of objects can be compared using a pan balance and standard units; objects can be described in terms of their weight and the materials they are made of; same size objects can have different weights when they are made of different materials.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scientific Practices</strong></td>
<td>Analyzing and interpreting data: students use “felt weight” to order 8 material cubes and analyze data to evaluate felt weight as a measurement tool; Engaging in argument from evidence: students use felt weight data as evidence to answer the question how good are our senses at measuring weight?</td>
</tr>
<tr>
<td><strong>Crosscutting Concepts</strong></td>
<td>Energy and Matter: flows, cycles, and conservation: weight can be used to track flows and cycles of matter.</td>
</tr>
</tbody>
</table>
III. Investigations

Click Investigating Weight

A. Investigating Weight 1, How good are our senses at comparing the weight of cubes?

This investigation challenges the idea that we can use “felt weight” to find out how the weights of two objects compare. Children’s initial understanding of weight is grounded in their perceptual experiences. However, the data students collect themselves lead them to understand that we can’t always rely on our senses to compare weights.

1. Experience the activity firsthand

a. Explore sensed weight

   Ask the investigation question: how good are our senses at comparing the weights of objects?

   Show participants three objects that appear identical but have different weights.

   If we want to order these objects by weight, can we use our sense of sight? hearing? touch?

   Have a volunteer order the boxes by weight.

b. Order cubes by felt weight

   Distribute a set of cubes to each group of 2-4 participants.

   Ask them to compare the weights of the cubes using their hands (felt weight) and record the order on the data table you have prepared (either posted on chart paper or projected using an electronic board or document camera).

2. Make meaning

Ask participants to look closely at the results.

Model strategies that help make sense of class data, for example,

- Use a color to highlight areas of the table where everyone is in agreement or where there are patterns.
- Use another color to highlight areas of disagreement.

Ask participants to use these results to make statements (or claims) that answer the investigation question and point to evidence in the data that supports the claim.

How good are our senses at comparing the weights of cubes?

Students typically find that felt weight isn’t very accurate when objects are very light (the woods) or very heavy (copper and steel) or when their weights are similar (woods, plastics). Felt weight is fine as long as the size of the objects is similar and the weights are quite different.
B. Investigating Weight 2, What does a pan balance tell us about the weight of the cubes?

The purpose of this investigation is to introduce the double pan balance, provide time for students to learn to use the balance, and appreciate the value of the instrument when felt weight fails them.

1. Ask participants to use the double pan balance to check the weight order of their cubes.

Have participants make necessary changes to the data (order of cubes by weight) they reported in Investigating weight 1.

2. Make Meaning discussion

Explain that the purpose for each discussion is included in the Teacher’s Guide. In this lesson, the discussion will reveal what students are thinking about the question How good are our senses at comparing weight? and students’ ideas about what additional information a pan balance does and doesn’t provide.

Tell participants that the focus question for this discussion is

- How did the pan balance help you answer the question How good are our senses at comparing weight?

Ask participants to imagine what students will say in response to this question and take a few minutes for them discuss these ideas.

C. Investigating Weight 3, How can we measure the weight of our cubes?

Students know the weight order of the cubes but not what the cubes weigh or how much more one cube weighs than another. The purpose of this investigation is to have students appreciate the necessity of using a single unit of measure to compare weight by seeing what happens when you don’t use a single measure!

1. Experience the activity firsthand

a. Put an unmarked strip of adding machine tape where everyone can see it.

- Ask a participant to order an oak, pine, and copper cube by weight.
- Ask him or her person to order these cubes this time by relative weight – how much heavier one cube is than another.
- Point out that they can’t know for sure how to space the cubes unless they know how much each one weighs.

b. Provide time for the group to generate some weight data

- Give each group an identical set of 3 cubes and a bucket of paper clips, washers, and counting bears.
- Give them 10 minutes to weigh the cubes using the items in the bucket and record their results on a data table you have prepared.

2. Make meaning

Record results. If groups used a single measure for all items or if no one used a mixture of measures, explain that students typically use a mixture of paper clips, washers and counting bears which they can quickly see makes it impossible for groups to agree on the weight of a cube or how much heavier one cube is than another.

<table>
<thead>
<tr>
<th>Group</th>
<th>Aluminum cube</th>
<th>Pine cube</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>9 bears, 4 paper clips</td>
<td>1 bear, 3 paper clips</td>
</tr>
<tr>
<td>Group B</td>
<td>10 washers, 21 paper clips</td>
<td>2 washers, 2 paper clips</td>
</tr>
</tbody>
</table>
Ask participants to discuss the question below.

When students are given a bucket of paper clips, washers, and bears and are left to decide how to weigh the cubes can be messy. Teachers are advised to let students deal with these quandaries themselves.

What do you think about this approach?

**D. Investigating Weight 4 How much heavier is one cube than another?**

Click 2, Weight, Investigation 4

The purpose of this investigation is to set the state for understanding why grams are used to measure weight. Students agree on a unit of weight (paper clips, washers, or bears), weigh the cubes, and record an agreed-upon class weight for each cube. They place the cubes on the measure line and are poised to understand why scientists all over the world use the gram as a standard measure of weight.

1. **Describe the activity**

Scroll to 2. Weigh the cubes

Explain that the Teacher’s Guide describes the logistics of this investigation. The class agrees upon a unit of measure for weight (bears, paper clips, or washers).

- Each kind of cube is weighed twice – there are 16 “weighings.”
- Students agree upon a final weight for each cube to put in the class data table.
- The teacher rolls out the measure line (which is now a weight line) from the kit
- Students put cubes in the appropriate place on the weight line.

2. **Experience placing cubes on a weight line firsthand**

Place an index card labeled “Paper Clips” next to the weight line.

Ask participants to imagine they had weighed the cubes in paper clips and to place the cubes in the appropriate places on the weight line.

If time permits and you think participants would benefit, repeat with a “bears,” or “washers” weight line.

3. **Make meaning**

Point out that

Sometimes the purpose of a discussion is to consolidate learning. This type of discussion is framed by three questions

What did we do?
Why did we do it?
What did we find out?
This discussion is an opportunity for students to put some of their math learning to work, for instance by asking, How many grams do we have to add to the PVC cube to make the weight equal to a copper cubes? How much heavier than a pine cube is the PVC cube? What cube is about 2X the weight of a PVC cube? etc.

It’s the same data on the measure line and in the data table, only represented two different ways.

4. The Concept Cartoon

Ask participants to find the link to the Weight Concept Cartoon (sidebar menu).

Look at this assessment together. Note that some teachers have students discuss – agree or disagree - their responses to these cartoon characters’ ideas in small groups and then write individual responses. These responses will help teachers decide next steps, for example, is the class ready to move on to the next investigation or will the class or a few individuals benefit from more experience measuring weight?
I. To the Workshop Leader

Introducing Investigating Standard Weight

Once they understand the need for standard units to measure weight, students readily accept the gram as the standard unit for scientific work the world over. Teachers will appreciate knowing that it takes a while – and lots of experience – before grams are really familiar. Is there something in the classroom that weighs just 1g? Can I find a 10g object? Would any of the materials cubes weigh about 10g? What about 100g? Can I think of something familiar that weights about 100g?

The first order of business in these investigations is becoming familiar with grams. Then comes an intriguing question: could very tiny objects (so small they don’t register weight on our hands or even on our scales) weigh something? Can something weigh less than a gram - can grams be divided into fractional units? Until students are convinced – by evidence and reasoning – that tiny things have weight, they will be unprepared for some important ideas about matter they’ll meet in Grade 5: that air is matter or that matter is composed of unbelievably tiny particles.

II. Investigating Standard Measure

This set of investigations introduces the gram as the standard unit of measure, asks what the 8 material cubes weigh in grams, provides a context to reason about whether tiny things have weight, and wraps up with a weighing/building challenge.

The Child and Scientist essays

Learning to measure weight is more than a set of procedures and teachers need to know what that is!

The Scientist Essay explains why standard units are important and provides insight into the practices of the scientific community.

Concept Cartoon

The Concept Cartoon is typically used as a formative assessment after Investigation 3. Learn what this assessment can reveal about students’ understanding of standard measure.
Materials and Preparation for this part of the workshop

Investigation 1
For the workshop leader:
- The plastic weight line
- 1 gram weight set
- 1 index card labeled “Grams”
- 1 object weighing approximately 1 pound (450 grams)

For each group of 2-4 participants:
- a pan balance
- 1 gram weight set

For each participant:
- 1 gram weight
- 1 large paper clip

Investigation 2
For the workshop leader:
- Prepare a class table on a whiteboard or flip chart for recording the gram weights of the cubes; an example is shown in Step 2.
- the plastic weight line
- 1 index card labeled “Grams”
- 1 or more sets of materials cubes (each participant needs one cube to weigh)
- 2 cubes that have been cut in half (kit)

For each group of 2-4 participants:
- 1 gram weight set
- a pan balance

Investigation 3
For the workshop leader:
- Draw an oversized 4-gram weight line on a flip chart or whiteboard.
- 1 8-gram piece of plasticene, rolled to the thickness of a pencil

For each group of 2-4 participants:
- 1 pan balance
- 1 5–gram weight
- 4 1–gram weights
- a plastic knife
- a small plate
- 1 desktop weight line labeled from 0 to 4 grams (Handout #2)
- approximately 10 grams of plasticene

Investigation 4
For the workshop leader:
If possible, gather the following materials to demonstrate the 10-10-10-10 activity.
- Styrofoam 10g
- aluminum foil 10g
- plasticene 10g
- wood stirrers 10g
- scissors
- Handout packet
III. Investigations

A. Investigating Standard Measures 1, How can grams help us compare weights?

The overarching purpose of this investigation is to introduce the gram as a standard unit of measure. By placing a variety of objects on a weight line, students see size and weight don’t always correspond.

1. Experience the activity firsthand

Explain the 1. Ask step introduces the set of gram weights students will use from now on.
Distribute objects or ask participants to select objects and weigh them in grams.
Roll out the weight line, including an index card that says “grams,” and ask participants to place objects on the weight line.

2. Review the weight line

Reiterate the following points about the weight line
- Weight is represented by distance from zero.
- Objects that are close to zero on the weight line weigh less than objects that are a greater distance from zero.
- The weight line is continuous: there is a place for every object on the weight line.
- The weight of an object can be between marks and numbers on the weight line.

3. Make meaning

Ask participants what they think about the advantages of grams as a unit of measure (rather than bears, paper clips, or washers, for example).
Call their attention to the objects arrayed along the weight line and ask what they notice about the relationship between weight and size.

- Are there objects that weigh about the same but have different sizes? How can this be?
- Are any objects just one gram different in weight? Could there be objects closer than 1 gram in weight?
- How do the sizes of the lightest (heaviest) objects compare? How much do they weigh? Any surprises?

How Investigating Standard Measures reflects the Science Framework

| Component Ideas about Matter and Its Interactions | The weight of objects can be compared using a pan balance and standard gram units; |
| Scientific Practices | Using mathematics and computational thinking: measurements of weight of same-sized samples of eight solid materials; 8 grams of plasticene can halved and halved again into smaller and smaller pieces until the pieces are too small to see or register on our scales |
| Crosscutting Concepts | Scale, proportion, and quantity: students use standard units to express and measure weight; they reason that matter can be subdivided into tinier and tinier pieces and each piece has weight; each tiny piece contributes to the total weight. |
B. Investigating Standard Measures 2, How much do the cubes weigh in grams?

Weighing the cubes in grams and placing them on the weight line is a straightforward activity that provides a context for introducing two ideas about weight: the additive and continuous nature of weight.

1. Experience the activity firsthand

Ask participants to weigh the 8 cubes in grams and place them on the weight line.

(Distribute the cubes and gather weight data as quickly as possible. If you are short on time, you can have participants click Resource Quick Links and look up the weights. Note that the weight of the woods will depend on factors such as humidity.)

Explain that in the classroom, each student weighs one cube and enters the data in a class table. There may be discrepancies between the weight measurements of the same kind of cube. The Teacher's Guide suggests that the students involved swap cubes and weigh them one more time.

2. Making meaning

Once the cubes are displayed on the weight line, explain that the purpose of this discussion is to bring forward the idea that weight is a property that can be increased in small or large increments. Ask questions such as

How much would I have to add to

- the acrylic cube to make it weigh the same as the PVC cube?
- the pine cube to make it weigh the same as the oak cube?
- the PCV cube to make it weigh the same as the copper cube?

Ask participants to imagine a cube made of another material and say where they think it might fit on the weight line. Have some fun: a cube made of banana, of brick, of butter, of whipped cream, etc.

Explain that the idea behind this thought experiment is that every point on the weight line represents a different weight, that there are no gaps; that there's a place for every object, and that new objects can be added between any two points on the line. This is referred to as the “continuous” nature of weight.

C. Investigating Standard Measures 3, Do very tiny things have weight?

The purpose of this investigation is to produce evidence that it's reasonable to believe that teeny, tiny things have weight.

1. Experience the activity firsthand

a. Rub an eraser so that participants can see the tiny “rubblings.” Pick up a piece of the rubber, place it in the hand of a participant and ask if this tiny thing has weight.

Explain that children commonly think that objects like a piece of dust or flakes of chalk don’t weigh anything. Encourage people to read Carol Smith’s Child and the Scientist essay.

b. Distribute Handout #, the desktop weight line and an 8 gram piece of Plasticine (you’ll save time if you weigh these out ahead of time).

(The Desktop Weight Line can be found in Resource Quick Links.)
Display a copy of the mini-weight line, (either tape a copy on the board, use a document camera, or the SMARTBoard).

Model an introduction to this activity: hold up the 8g piece of Plasticine and ask 
“If I cut this is half, how much will each piece weigh?” [4g] 
 “Where does a 4g piece go on the weight line?” [Make the mark.]
 “If I cut the remaining 4g piece in half, how much will each piece weigh? [2g]
 “Where does a 2g piece go on the weight line?” [Make the mark.]

c. Ask participants to work in pairs and follow your narration below.
• Begin with an 8 gram piece of Plasticine
• Divide the piece of Plasticine into two equal pieces and place one of the pieces on the 4 gram mark on the weight line.
• Divide the other 4 gram piece into two equal pieces and place one of these on the 2 gram mark on the weight line.
• Divide the other 2 gram piece in half and put one piece on the 1 gram mark.
• Divide the remaining 1 gram piece in half and decide where this piece goes on the weight line.
• Decide where the half of the half-gram piece goes, and a half of the one-quarter-gram piece goes.


d. Lead a discussion
Ask participants to do the same thought experiment they will use in their classrooms.

As fine motor skills limit the size of the pieces you can continue to subdivide, try this thought experiment (an experiment you do in your imagination):

Imagine you had microscopic hands and tiny little scissors and could keep cutting the pieces of Plasticine in half as many times as you want.

• Would you ever run out of Plasticine?
• As the pieces of Plasticine get smaller and smaller, will you ever get to zero on the weight line?
• Can you ever have a piece of Plasticine—no matter how tiny—on the other side of zero on the weight line?
• Do you think objects have weight even if we can’t feel the weight?


e. Return to the Investigation Question:
Ask participants to take a few minutes to discuss their ideas about why Do tiny things have weight? is an important question for students who are learning about matter.
D. Investigating Standard Measures 4, The 10-10-10-10 Challenge

This investigation taps into students’ creativity and imagination at the same time they practice weighing objects in grams. When they see what 10 grams of aluminum, foam, wood, and Plasticine look like, it becomes clear that some materials take up more space for the same amount of weight than others.

1. Explain that you will not do this investigation in the workshop.

Ask participants to show with their hands how much space they think 10g of each material will take up. (They have just seen 8g of Plasticine so should be able to make a reasonable prediction about this material!) Encourage participants to tell their students to weigh carefully, be creative, and have fun!

2. The additive nature of weight

Explain that after students complete their constructions, the teacher asks each team to predict the weight of the final product. Note that a seated pan balance accommodates these objects more readily than a hanging pan balance.

The final weigh-in can be quite exciting! If the final weight is more or less than 40g, the teacher asks students to figure out where to find missing materials or what they might do to hit the 40g target.

3. Make meaning

Explain that the discussion focuses on three big ideas about matter and weight

- Each material weighed the same (10g). What did you notice about the amount of space they took up? Property of materials is its “heaviness for size,” which is a precursor idea to the concept of density
- You began with 10g of each material. Some materials were reshaped (the plasticene was divided into pieces, squished, stretched; the aluminum was bent; some of the wood was broken into pieces). Did the weight change? Explain. [weight is conserved during transformations of matter]
- Did the total weight equal the sum of the weights of the parts? [weight is additive in nature; weight stays the same as long as no matter is added and no matter is taken away]

Explain that this is an opportunity for teachers to touch on engineering ideas.

- The properties of each material determine its function in 10-10-10-10 construction, e.g., if a team wanted “legs” to hold the foam block off the table, wooden sticks would be a better choice than Plasticine or aluminum foil.
I. To the Workshop Leader

Volume is challenging for students; you won’t get any disagreement from their teachers on this point! Your challenge in this part of the workshop is to make the case that children’s understanding of volume develops over time through multiple experiences in a variety of contexts. And, that these four experiences with volume are a beginning - they set the stage for more in-depth investigations of volume in Grade 4. Teachers will appreciate knowing the rationales for the activities in this set of investigations and how they serve as a springboard for further learning.

II. Section 4, Investigation Volume, Investigations 1-4

The investigations in this section introduce volume, distinguishing the amount of space an object takes up from weight, height, area, and other measures. A cube 1cm x 1cm x 1cm is introduced as the standard measure of volume. Students discover that objects of equal volumes can have very different weights, an idea that is a precursor to the concept of density that students encounter in middle school.
Materials and Preparation for this part of the workshop

**Investigating Volume 1**

For the Workshop Leader:
- 1 block of Styrofoam (approx. 10 cm x 10 cm x 20 cm)
- 1 pillar candle #1 (approx. 8 cm diameter x 16 cm tall)
- 1 small maple block (from 4 piece wood block set)
- Several creations from the 10–10–10–10 Challenge, if available

For each group of 2-4 participants:
- 1 small cube (cubic centimeter block)
- 1 copper cube (from the set of materials cubes)
- 1 pine cube (from the set of materials cubes)
- 1 100–gram piece of plasticene

**Investigating Volume 2**

For Workshop Leader
- Prepare and post a class table labeled “Order of Blocks by Volume”; an example is given in Step 2.
- The class volume line from the previous session (with the Styrofoam, maple block, cubes, et al.)
- Label sets of 4 wooden blocks A, B, C, D; see image in Step 1.

For each group of 2-4 participants:
- 1 set of 4 wood blocks labeled A, B, C, and D, or enough blocks for each student to have 1 block
- At least 75 cubic centimeter blocks

**Investigating Volume 3**

For each participant:
- 1 plastic knife
- 1 small plate
- 8 centimeter cubes
- Approximately 10 cubic centimeters of plasticene

**Investigating Volume 4**

For the group:
- Histogram 1: Number of Materials in Our Objects
- Histogram 2: Materials Our Objects are Made of
- Histogram 3: Estimated Volume of Our Objects
- The class weight line
- 3 volume reference blocks: 1, 10, 100 cubic centimeters (see the photo in Step 2).
  - 10 cubic centimeter reference is created by taping 10 centimeter cubes together
  - 100 cubic centimeter reference is created by taping 5 maple blocks labeled B (20 cubic centimeters) together

For each group of 2-4 participants:
- 1 gram weight set
- a pan balance

For each participant:
- 1 personal or classroom object
How Investigating Volume reflects the Science Framework

| Component Ideas about Matter and Its Interactions | Volume describes the amount of 3-D space an object takes up. The volumes of objects can be compared. Two solid objects cannot occupy the same space. Matter has weight and volume. |
| Scientific Practices | Analyzing and interpreting data: students collect data about the weight, volume, and materials of a collection of objects and make evidence-based claims. Using mathematics and computational thinking: students investigate volume when an object is transformed |
| Crosscutting Concepts | Scale, proportion, and quantity: the volumes of objects can be quantified and compared. |

III. Investigations

Click 4. Volume, Investigation 1

A. Investigating Volume 1, What does it mean to take up space?

This investigation introduces the concept of volume (and the term) which may be new to 3rd grade students and difficult for them to separate from other measures that also describe an object's size (e.g., weight, height, length, area, perimeter).

1. Click 1. Ask the question

Take time to describe and model this step in the investigation: learning about volume can’t be rushed.

a. Explain that the lesson begins with the 10-10-10-10 student-created objects from the last investigation. (If possible, show a sample 10-10-10-10 creation.)

The following question is designed to call students’ attention to the different amounts of space 10g of each material takes up.

All four materials weighted exactly the same – 10 grams. What differences did you notice about how much of each material there was?

Ask participants to think about what students might say in response. [more of, less of, bigger, smaller]

Suggest that teachers might ask students to “say more” about these ideas. The goal is to have the group reach consensus that what’s different is the amount of space 10g of each material takes up.

b. Choosing language and using hands

Scroll to the Talking Points box and point out that the term “volume” is not introduced until the very end of the lesson. Until then the phrase “takes up space” is used to emphasize the three-dimensional nature of volume.

Scroll to the modeling 3-dimensional objects box

As the discussion winds down, tell students that, just as objects have height and weight, every object also takes up space. Put the tall pillar candle on the floor and use your hands to define the amount of space the candle takes up, moving hands around and above the candle, to illustrate how much space this candle takes up.

Modeling 3-dimensional objects: To demonstrate the meaning of how much space an object takes up, use both hands, in motion, to show all of the physical boundaries of an object — its top and bottom, its left and right boundaries, its front and back boundaries. By keeping your hands in motion, you focus attention on the size of the whole object — not only its height or length — and embody the three-dimensionality of the object.

Next place the maple block beside the candle and move your fingers around the block in a similar way, to illustrate how much space the wood block takes up.

Finally, invite some comparisons:

**Which object takes up more space, the candle or the block of wood?**

**What about this block of Styrofoam? How does it compare?**

Leave the Styrofoam block, pillar candle, and maple block in order for later reference.
Encourage participants to use their hands as they describe the three-dimensional nature of volume (and model this yourself during the workshop).

c. Order three objects by volume

Place a large block of Styrofoam, a pillar candle, and a small maple block where everyone can see them and ask a volunteer to order them by the amount of space they take up.

2. Experience the activity firsthand

- Distribute 3 cubes (cm cube, pine cube, copper cube) and a 100g piece of Plasticine to each group of 2-4 participants and have participants order them from the least to the greatest amount of space they take up.
- Ask participants to consider the reason why there are two cubes with the same volume in this set of materials. [can students can separate volume from weight?]
- Project the Notebook page and ask participants how they think students will respond to the question Do you think a tiny ant takes up space? [this is a chance to distinguish weight and volume: having just addressed the question Do tiny things have weight?, students may confuse weight and volume]
- Remind participants that the term “volume” has not yet been introduced.

3. Make meaning

Ask participants to combine the two sets of materials they have ordered by the amount of space they take up into a single ordered volume line.

Take a few minutes for participants to raise any questions they have about leading this activity or challenges they think their students might face.

Tell participants that at the end of the discussion, the teacher introduces the term “volume,” and distinguishes its use in science from other uses, e.g., the amount of sound.

B. Investigating Volume 2, How can centimeter cubes help us measure volume?

The purpose of this investigation is to raise students’ awareness of the need for a standard measure for volume and to introduce them to the cubic centimeter that they can use to quantify and compare volumes.

Click Investigating volume 2 and scroll to 1. Think about measuring volume

1. Experience the activity firsthand

a. Explain that the 1. Ask step is replaced by a discussion of units are used to measure things. This short activity makes the case for needing units to measure and compare volumes.
b. Distribute sets of 4 blocks labeled A, B, C, D.
   • Ask participants to order the blocks by volume. These materials (the blocks) are designed so the volumes are difficult to compare.
   • Record each group’s order on a group data table (that you prepared ahead of time and post or project on the SMARTBoard) from least to most volume

<table>
<thead>
<tr>
<th>Model of table for recording the order of blocks by volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 Order</td>
</tr>
<tr>
<td>Group 2 Order</td>
</tr>
<tr>
<td>Group 3 Order</td>
</tr>
<tr>
<td>Group 4 Order</td>
</tr>
<tr>
<td>Group 5 Order</td>
</tr>
<tr>
<td>Measured Order*</td>
</tr>
</tbody>
</table>

• Ask participants to use the data to answer the question

_How good are our senses at measuring volume?_

• Explain that typically not everyone’s estimated order is the same and students are pleased to learn they can use centimeter cubes to measure and compare.

c. Use the cm cubes to measure
   • Distribute cm cubes.
   • Explore the cubic centimeters and focus on the photograph.
   • Explain that many 3rd graders find it challenging to use the cubes to measure the volumes of the blocks. A good strategy is to replicate the object (make a twin) with cubes, however, making a replica is not always easy for 3rd graders to accomplish. **Step 4. Measure the volume of the blocks** describes what teachers may expect in the classroom.

| TIP | The plastic centimeter cubes have a volume of 1cc (cubic centimeter) and each cubic centimeter of this material weighs 1g. However, in this curriculum the cubes are used ONLY to measure volume. The hexagram metric weights are used to measure weight. Students often confuse weight and volume so it’s very important to use the cubes to measure volume only.

• Ask participants to use the cm cubes to measure and record the measured order on the data table.
• There is no discussion in this investigation.

d. Explain that in the Grade 4 curriculum, students will build on this introduction to centimeter cubes. They use these same cubes to estimate and measure the volume of irregularly shaped objects, calibrate a container to measure the volume of liquids in cubic centimeters, and investigate measuring volume by displacement of water.
C. Investigating Volume 3, Does changing the shape of an object change its volume?

It’s easy to understand why someone might think that changing the shape of an object changes the volume! In this investigation students collect evidence that as long as no matter is added or taken away, changing the shape of an object doesn’t change the volume.

1. Experience the investigation firsthand

Click Investigation 3.

a. Ask the question

- Explain that before students begin to use materials to investigate, they must be able to distinguish shape from volume.
- Click 1. Ask the question and review the sequence suggested in the Teacher’s Guide (i) define “shape” and “volume,” (ii) check for understanding, (iii) ask the investigation question, (iv) use the three scenarios to help students understand the meaning of the investigation question

b. Explore shape and volume with cubes

This activity provides evidence that changing the shape of an object (in this case a structure built of cubes) does not change its volume.

Distribute 8 centimeter cubes to each participant.

Guide participants through the activity sequence outlined in the Teacher’s Guide

- Build rectangle 4 stories tall and describe the volume (8 cubic centimeters)
- Predict the volume if you change the shape.
- Construct a new building either one-, two-, or three-, or four stories and describe the volume

c. Explore shape and volume with Plasticine cubes

Distribute approximately 10 cubic centimeters of Plasticene to each participant.

Guide participants through the activity sequence.

- Make 8 centimeter cubes (use one of the cm cubes from the kit as a guide)
- Create a building using all 8 cubes
- Keep 4 cubes in a cube shape but use the other 4 in any way or shape

d. Make meaning

Explain that the purpose of this discussion is to bring forward students’ ideas about volume and see if they can use evidence from their investigation to support their position (no, the volume doesn’t change, or yes, the volume does change) with evidence and reasoning.

Click the formative assessment icon and listen to a little bit of this discussion from a 3rd grade classroom.

Provide time for participants to discuss what they noticed in these few minutes of a class discussion.

Is there evidence that students understand that the volume of 8cc of Plasticine stays the same even if you change the shape?
e. Formative Assessment Volume Concept Cartoon

Point out the Concept Cartoon that is designed for teachers to assess their students’ (a) understanding of volume as a measure of the amount of 3-D space an object occupies and (b) ability to distinguish volume from area or height.

If time permits, look at this item together, including the What to look for in student responses section—a rubric for teachers.

D. Investigating Volume 4, How can we describe our personal objects?

The purpose of the final investigation is to consolidate the learning from the previous 16 investigations by gathering weight, volume, and materials data about all the personal objects.

1. Experience the activity firsthand.

Post the three histograms you prepared ahead of time.

Locate a weight line where participants can place their objects

a. Explain the purpose of the investigation and ask each participant to

• select an object to stand in for a personal object (something that will fit in a pocket, e.g., a cellphone, lipstick, marker)
• estimate the (i) weight, (ii) the volume, and (iii) describe the materials it is made of.
• weigh the object and put the object on the weight line
• use the 1cc, 10cc, 100cc volume blocks you have prepared to estimate the volume and record their initials on the appropriate histogram
• Record the number of materials in the object and the kinds of materials on appropriate histograms

b. Make claims about the personal objects

• Explain that the focus question is How can we describe our personal objects? and the challenge for the teacher is helping students learn how to find evidence in the data that will back up a claim statement.
• You will need to model the process for participants: find the data that can support a claim, make the claim, point to (refer to) the evidence in the graph or weight line.
• Ask participants to make claims about with the # of materials in the collection of objects and point to the data in the histogram.

   How can we describe the number of materials our objects are made of?

   • Facilitate participants’ discussion, making claims and pointing to the evidence in on the histogram.
   • Repeat for kind of materials and volume of objects.
   • Finally, turn to the weight line and ask

   How can we describe the weight of our collection of objects?

   There will be a number of possible claims that the weight data will support.

2. Wrap up discussion

The goal of this investigation is to use skills and concepts related to materials, weight, and volume and to gain experience using data representations (graphs and the weight line).

Ask participants to reflect on this data gathering activity as a way for them to achieve the goal.