IS1

Grade Five Instructional Segment 1: What is Matter Made of?

Grade five students delve into the most abstract scientific concept they have yet confronted, **developing and refining a model [SEP-2]** that describes matter as being made up of particles that are too small to see. By investigating a series of phenomena that emphasize the properties of materials and the **conservation of matter [CCC-5]** (the idea that material is not created or destroyed but just moves around within a system), students recognize that a model with matter as particles can explain many of the features they observe. This instructional segment has three main sections that progress from the observable down to the abstract: (1) describing materials; (2) mixing and changing materials; and (3) developing and applying a model of materials.

GRADE FIVE INSTRUCTIONAL SEGMENT 1: WHAT IS MATTER MADE OF?

Guiding Questions

- What causes different materials to have different properties?
- How do materials change when they dissolve, evaporate, melt, or mix together?
- What are the differences between solids, liquids, and gases?

Performance Expectations

Students who demonstrate understanding can do the following:

5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen. [Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [*Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.*]

5-PS1-2. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved. [Clarification Statement: Examples of reactions or changes could include phase changes, dissolving, and mixing that forms new substances.] [*Assessment Boundary: Assessment does not include distinguishing mass and weight.*]

5-PS1-3. Make observations and measurements to identify materials based on their properties. [Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.] [*Assessment Boundary: Assessment does not include density or distinguishing mass and weight.*]

5-PS1-4. Conduct an investigation to determine whether the mixing of two or more substances results in new substances. [Clarification Statement: **Examples of combinations that do not produce new substances could include sand and water. Examples of combinations that do produce new substances could include baking soda and vinegar or milk and vinegar (CA).**]

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3–5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. [Clarification Statement: Examples of models could include diagrams, and flow charts.]

California clarification statements that are bolded and followed by **CA** *were incorporated by the California Science Expert Review Panel.*

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-1] Asking Questions and Defining Problems [SEP-2] Developing and Using Models [SEP-3] Planning and Carrying Out Investigations [SEP-4] Analyzing and Interpreting Data [SEP-5] Using Mathematics and Computational Thinking [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering) [SEP-7] Engaging in Argument from Evidence [SEP-8] Obtaining, Evaluating, and Communicating Information	PS1.A: Structure and Properties of Matter PS1.B: Chemical Reactions	[CCC-1] Patterns [CCC-2] Cause and Effect: Mechanism and Explanation [CCC-3] Scale, Proportion, and Quantity [CCC-4] Systems and System Models

Highlighted California Environmental Principles and Concepts:

Principle IV The exchange of matter between natural systems and human societies affects the long-term functioning of both.

CA CCSS Math Connections: 5.MD.3a, b; 5.MD.4

CA CCSS for ELA/Literacy Connections: SL.5.1, 4, 5

CA ELD Standards Connections: ELD.PI.5.1, 6

Engineering Connection: Selecting Appropriate Materials

Every material has specific properties. When students need to select the appropriate materials for an engineering challenge, their attention is drawn to these differences. This instructional segment can begin by providing students different materials and giving them the challenge to construct a tall tower that can bear a heavy mass. Which materials are best suited to the task? Students can devise techniques for measuring or quantifying many of these properties. How can students combine materials or modify their structure so that they work better? They can increase the strength of paper by rolling it into tubes, index cards by gluing them together with glue sticks, or spaghetti strands by taping several together. Testing the structures using a consistent procedure allows students to identify the specific mechanism of failure such as crushing and buckling, stretching and tearing (3–5-ETS1-3). Do different materials fail in different ways?

From everyday experience, students can recognize and name a wide variety of materials without even thinking about how they do it. Teachers need to make the implicit knowledge explicit, asking students how they know that one material is wood while another is stainless steel or aluminum. What properties can be used to describe a substance, classify it, and differentiate it from others? The most visible property, color, has only limited use because it can be changed with a thin layer of paint over a solid or drop of food coloring in a liquid. Instead, students learn to ask more detailed questions about materials. Students apply and expand the vocabulary they learned in grade two to describe material properties (2-PS1-1), but now they are ready to be more quantitative about their descriptions, making measurements of certain properties and using them to distinguish between materials (5-PS1-3). Making precise measurements can be motivated by the constraints considered when **defining engineering problems [SEP-1]**. For example, if we need to design a spoon that will not heat up more than 10 degrees when placed in boiling water, which material works best? Students can measure the heat conduction properties of several materials using a consistent test. Students can measure the melting temperature of different materials such as wax, chocolate, and ice to decide which material would make the best decorative sculpture for a summer birthday party. Students can measure the strength of different materials to determine which one to use to support a bridge that will bend without breaking when a toy car drives across it. Students can identify "mystery" powders based upon how much of each powder they can dissolve in a cup of water or how the powder reacts with various other ingredients.

To motivate the next section about physical and chemical changes to materials, students can think about all the properties that change when they mix materials to bake a cake (which can be done in class if permitted by school rules). Students can explain their thinking about the formative assessment probe: When you bake a cake, does the finished cake weigh more or less than the batter that you put in the oven? Does the batter weigh the same as all the raw ingredients separately? Many students explain that the cake dries out so it weighs less, but some may argue that it puffs up and so it weighs more. The question motivates a series of **investigations [SEP-3]** exploring how the mass of a material changes (or does not) under different conditions. Students can make qualitative comparisons using simple mechanical balances with cups or platforms on either side or make more precise measurements using calibrated triple-beam or digital balances. Students can work with the term *mass* rather than *weight* at this grade (the terms are used interchangeably in this instructional segment). Students can measure the mass of an object and then heat or cool it to see if its mass changes. Some materials get hot enough that they melt. Does melting or freezing change the mass of material?

When collecting real data, there is always the possibility that real-world factors will interfere with the intent of an investigation. In this case, precise measurements by scientists reveal no difference as a material is heated or cooled, melted or frozen—a given amount of material always has the same mass. If students use precise digital balances, they may observe small differences between their measurements that represent measurement errors or the effects of condensation and evaporation. Before making measurements, teachers will need to set up the comparison by having students make repeated measurements of the same object to establish how big a change needs to be observed before they can be confident that the change is real and not just the imprecision of the balance they are using. Similarly, they can emphasize the very large differences in properties between solids and liquids. Does the mass change as dramatically as the properties? Having students predict the **magnitude [CCC-3]** of differences ahead of time using this information gives them better context for **interpreting their data [SEP-4]**.

Next, students explore what happens when they mix substances together. How does mixing affect the properties and mass of the materials? Teachers give students substances to mix, some of which undergo chemical reactions and others that simply form mixtures. Students mix different combinations of mystery powders (such as baking soda, washing soda, flour, powdered lemonade, calcium chloride, corn starch, and Epsom salts) and liquids (water, vinegar, lemon juice, tincture of iodine, some mixed in with the juice from purple cabbage, which changes color as the pH changes) together in plastic zip bags and observe what happens (Sibenaller 2013). Some mixtures cause dramatic, unusual changes and reactions, while others are uneventful. Students should use their observations from before, during, and after mixing to support an **argument [SEP-7]** that a new substance formed (or did not form) when the powders and liquids were mixed together (5-PS1-4). They should notice patterns when certain groups of powders and liquids mix together and patterns in the types of unusual changes that can occur. Teachers can label these changes with the term *chemical reactions* and discuss the meaning of each of the two words. Common signs of chemical reactions are temperature changes (cold and hot packs), formation of a gas (effervescent tablet and water), color change (metal rusting), formation of a solid (stalactites and stalagmites/hard water build up), a change in smell (baking cookies or bread), and/or emission of light (glow stick). Students should be able to observe all of these (except glowing light) from their mixtures in the bags and should be able to describe how the properties of the new substance(s) are different from the properties of the original ingredients.

Clearly there are major changes inside some of the bags, but does the mass change? Students can measure the mass of the bags before, during, and after each reaction (5-PS1-2). In theory, the mass does not change even in bags that fizz and puff up with gas. Students can compare high-quality plastic zip bags with cheaper versions and see that some bags leak gas more than others (causing the mass to slowly drop as the fizzing progresses). This observation leads to an important and often unexpected discovery: gas has mass. Students can confirm this idea by comparing the mass of an empty balloon to the mass of one blown up with air (hanging the balloons on opposite ends of a meter stick, which can be used as a balance by hanging the meter stick from a string at its center). They can also confirm this by placing an empty cup on a balance, mixing chemicals that fizz in the cup, and watching the mass of the cup decrease as the reaction progresses. If they repeat this same reaction in a well-sealed bag, they will see that the mass stays constant. Based on their observations, students should be able to answer the original question about the mass of a cake and its ingredients—it may weigh less after cooking because some of the mass might have escaped into the air as a gas. The air in the room, however, would now weigh more (if you could measure it!).

While students have everyday experience with air as a gas, this is the first time that they explicitly explore the properties of gases in the California Next Generation Science Standards (CA NGSS). Students can explore different phenomena to characterize solids, liquids, and gases with the goal of describing and comparing their properties. How do we interact with each of the different states of matter (how do they look or feel)? Students investigated solids and liquids in grade two (2-PS2-1), so grade five emphasizes gases. Students can feel gases by moving their hand back and forth through the air or constructing windmills or parachutes to show how air exerts forces on objects. To probe students' initial **models [SEP-2]** of what gases are, teachers can have them hold a syringe filled with air and then draw and label what is inside the syringe (What would the air look like if you could see it under a microscope? How can you draw it?). Then, they hold their finger on the end of the syringe to trap the air inside and try to compress the plunger (they can make force diagrams using arrows like the diagrams in third grade 3-PS2-1). How does the air change? Students' initial ideas vary, but they can all be guided to recognize that the amount of air in the syringe does not change because it cannot escape (figure 4.19). But which of these models is correct?

Figure 4.19. Facsimiles of Students' Initial Models of Air

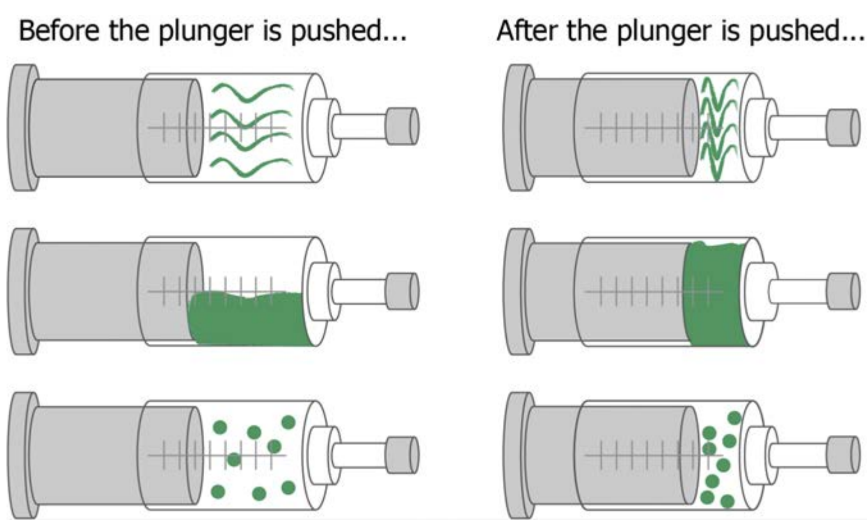
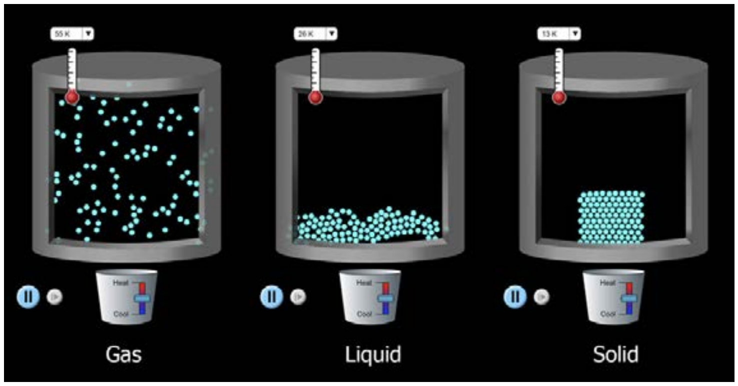


Illustration by M. d'Alessio
Long description of Figure 4.19.

Students correctly identify that the amount of material inside the syringe must be the same because nothing can escape. Students have different models of how that air looks or is distributed inside the syringe.

To distinguish between the different models, students can observe dust settling in a room or smoke from a match after it has been blown out. Video clips of these phenomena up close (try searching for "Dust, Brownian motion") reveal something interesting: even as the overall motion of the particles is a downward drift due to gravity, some of the particles suddenly move up. Students know from grade three that the only way to make something move upwards is to push or pull it upwards. What can be pushing the dust? The answer is that particles of air that are too tiny to see even with a microscope crash into the larger dust particles and alter their paths. Students then investigate computer simulations of matter that show a particle model of materials (figure 4.20).

Figure 4.20. Computer Simulation of Particles of Neon in Three States: Gas, Liquid, and Solid



Source: PhET n.d.c.
Long description of Figure 4.20.

Students can now return to all the different phenomena they have investigated in this instructional segment and look at them through the lens of the model. How do solids differ from liquids or gases? In the gas, there is so much empty space between the particles that we can often see right through it (which is why air is clear). In a solid, the particles are stacked in a defined structure and therefore are stronger and resist pushing and deforming more than liquids. How does the model explain the fact that mass stays the same even when you mix materials together, warm them up, cool them down, melt, or boil them? Each particle has its own mass, which does not change as the particles move around. Each of these processes involves changing the position and speed of the particles, but does not affect their mass. Students can draw a model of an empty balloon and one filled with air using this model and it becomes much easier to explain why the full balloon weighs more—there are more particles of air inside. They can draw a sugar cube dissolving in water by representing the cube as an array of stacked particles that disperse from one another when they enter the water. Each individual particle is too small to see, though collections of many particles together are visible. This leads to a discussion of the word disappear and its prefix (CA CCSS for ELA/Literacy RF.3.3a)—while particles can *disappear* (i.e., stop being visible), they do not go away or get destroyed. This concept of the conservation of matter is fundamental to all science. It also is the foundation of California's Environmental Principles and Concepts (EP&C) IV: "The exchange of matter between natural systems and human societies affects the long-term functioning of both." Pollution does not just go away, it ends up in air, water, soil, and in our bodies. Just as students are able to trace individual particles of sugar as they dissolve in water, scientists can follow particles of toxic pollution throughout waterways, in the air, and even into the human body.

This instructional segment emphasizes the evidence that builds up to a model and then the subsequent application of the model to explaining a wide variety of phenomena. Vocabulary is not a focus. At this grade level, the term *particle* is used generically for the scientific terms *atom* and *molecule* because the distinction between them is beyond grade five. Students need some names for the different types of particles in a mixture or solution (e.g., water particles, sugar particles, oxygen particles). However, the names of specific elements are introduced only as needed to describe and discuss their observations about matter-related phenomena, and the nature of the differences between different elements is not stressed.

GRADE FIVE VIGNETTE 4.3: PANCAKE ENGINEERING

Performance Expectations

Students who demonstrate understanding can do the following:

Students who demonstrate understanding can do the following:

5-PS1-4. Conduct an investigation to determine whether the mixing of two or more substances results in new substances. [Clarification Statement: **Examples of combinations that do not produce new substances could include sand and water. Examples of combinations that do produce new substances could include baking soda and vinegar or milk and vinegar (CA).**]

3–5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3–5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3–5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

California clarification statements that are bolded and followed by **CA** *were incorporated by the California Science Expert Review Panel.*

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-1] Asking Questions and Defining Problems [SEP-3] Planning and Carrying Out Investigations [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering) [SEP-8] Obtaining, Evaluating, and Communicating Information	PS1.B Chemical Reactions ETS1.A: Defining and Delimiting Engineering Problems ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution	[CCC-2] Cause and Effect: Mechanism and Explanation [CCC-4] Systems and System Models

CA CCSS Math Connections: 5.MD.3, 5.MD.4

CA CCSS for ELA/Literacy Connections: SL.5.1.a-d

CA ELD Standards Connections: ELD.PI.1, 3, 9

GRADE FIVE VIGNETTE 4.3: PANCAKE ENGINEERING

Introduction

What does cooking have to do with engineering? What effects do certain ingredients have on others? Mixing pancake batter creates a chemical system with interacting components, and each ingredient plays a different role within the system. This fifth-grade activity merges scientific understanding of chemical reactions and systems with an engineering design challenge to make the perfect pancake.

Day 1: Define Criteria

What does a perfect pancake look like?

Students come up with the criteria for their ideal pancake: golden brown, fluffy, and tasty.

Day 2: Plan Solutions

What happens when we mix two materials?

Students investigate what happens when two ingredients are mixed together in order to understand the behavior of different ingredients. They vary proportions and identify trends. Finally, students try cooking their pancakes and discover something is missing.

Day 3: Create, Evaluate, and Improve

What is the optimal proportion of ingredients?

Students spend the lesson mixing ingredients, cooking the pancakes, evaluating the results, and making modifications to achieve their ideal pancake.

Day 4: Communicate Results

What changes did I make?

Students create a summary document explaining what they changed from one trial to the next. The class then compares recipes from the "best" pancakes to find patterns. Students then decide on three recipes to try to repeat and see if the results are the same.

Day 1: Defining Criteria

Everyday phenomenon: Pancakes are fluffy, golden brown, and tasty.

Mrs. C always told her students that "engineering is everywhere!" In this activity, students engineered the "perfect pancake." Mrs. C assigned six students to read parts from a script where they played the roles of students waiting for their food at a pancake restaurant. The characters argued about whether they liked their pancakes fluffy or thin and described the "secret recipes" used in their houses. Mrs. C showed a diagram of the stages of the engineering design process and asked students to discuss how different lines from the script related to stages in the process. In order for Mrs. C's students to design the perfect pancake, they needed to **define the problem [SEP-1]** by specifying the criteria (3–5-ETS1-1). How would they decide if they had succeeded? The class decided that the pancakes should be golden brown, fluffy, and tasty. But how would they measure these properties? For golden brown, the students decided that they could compare their pancake to a color palette that

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shows different shades of brown and agree on a particular shade that they consider "ideal." A "fluffy" pancake should rise tall; students decided to measure the pancake height by sticking a toothpick in the center and seeing how deep it went by holding a ruler next to it. The last criterion of "tasty" is subjective. Unlike science, which strives to be completely objective, engineering deals with designing solutions that meet people's needs and desires. The engineers that design a car, for example, pay as much attention to the car's appearance as they do to its mechanical systems. Even though the criteria were subjective, students still needed a way to track and record their opinions. They decided to rate the tastiness of the pancake using a one to five star scale.

Day 2: Planning Solutions

Investigative phenomenon: The properties of batter depend on how much flour, baking powder, and water are combined.

Students did not get a recipe to follow—they used a design process to eventually determine an ideal combination of ingredients. As in many design problems, students needed to gather information about the materials available to them to plan their solution. Mrs. C provided students whole-wheat flour, oat flour, water, and baking powder. Students chose two different ingredients to mix together and saw what happened. Baking powder and water fizz, water and flour turn into thick dough, and baking powder and flour seem unchanged by their interaction. Different students tested out different relative proportions of the ingredients and described their results to the class so that they could identify **trends or patterns [CCC-1]** (figure 4.21). Mrs. C emphasized that it is important that students measure carefully so that they can make meaningful comparisons between one recipe and another. To facilitate comparisons, Mrs. C added the constraint (part of **defining the problem [SEP-1]**) that every pancake must always use exactly one scoop of flour. Students could vary the other ingredients, but the flour had to remain constant. Students noticed that more baking powder caused more fizzing and that wheat flour seemed to make thicker mixtures than oat flour when combined with identical amounts of water. After exploring the interactions, students observed what happens when different proportions were used. Mrs. C described a pancake recipe as a chemical **system [CCC-4]**. The ingredients were components of the system and the day's tests characterized different interactions between the components when they were in simple two-ingredient systems. Students combined these ideas into a **model [SEP-2]** of the full system as they adjusted their recipes in the upcoming part of the lesson. Groups of students used their observations of the simple systems to decide the proportions of each ingredient to use for their first test pancake. Their discussions were simple **arguments supported by observational evidence [SEP-7]**: "I think we should use two parts water to one part flour because the batter was too thick in the 1:1 mixture." Mrs. C helped students cook their one test pancake on the griddle.

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Investigative phenomenon: None of the pancakes turn brown.

Watching the pancakes cook, every group decided its test pancake was a “failure” because none turned brown! What could be missing from the system? Students measured the thickness, compared the white pancakes to the color chart, and recorded the results on a data sheet. Mrs. C told students real engineers get excited when their design fails because it gives them the opportunity to learn more about the system and to try again.

Figure 4.21. Students Compare Different Batter Recipes

Long description of Figure 4.21.

Day 3: Create, Evaluate, and Improve

Investigative phenomenon: What combination of ingredients will produce the perfect pancake?

Mrs. C wanted students to experience the power of the iterative process of engineering. Clearly something was missing from their previous pancakes, so Mrs. C offered two additional ingredients today: pureed bananas (one banana and one-quarter cup water pureed in a blender) and vanilla extract. Students began the lesson by mixing ingredients using the knowledge they gained about each ingredient in the prior lesson and adding the new ingredients. Parent volunteers helped students cook their pancakes and evaluate the results (there were four cooking stations set up in different corners of the classroom). How fluffy was it? Was it golden brown? How did it taste? Mrs. C reminded the students to carefully write down the proportions they used after each attempt so that they could systematically change ingredients or proportions to get better results. One student added a lot of vanilla (“because it’s brown”), but his pancake still did not turn brown. Another student used banana puree instead of water (“I love bananas”) and her pancake was the first to turn a beautiful golden brown.

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Soon, students were experimenting with different proportions of banana and water (figure 4.22). Mrs. C circulated while the pancakes were cooking, asking students to apply their mental model about the role of each ingredient by asking things such as, Looking at these two pancakes, which one do you think has more baking powder? Do you think that this pancake has any banana in it? How can you tell? Wow, that pancake is really thin. What do you think you could add to improve it? Based on their discoveries and comparisons with peers, students made modifications to achieve their perfect pancake. Students enjoyed eating their successes!

Figure 4.22. Students Systematically Test Different Recipes

(Amount used in teaspoons)				
Water	2	1.5	1	0
Banana puree	0	0.5	1	2

Long description of Figure 4.22.

Day 4: Communicating Results

During day 3, students carefully documented their ingredients and results. This day, Mrs. C asked them to reflect on the sequence of mixtures they used. The students made a "storyboard" showing the succession of pancakes (figure 4.23). For each frame, the students described in words how the pancake turned out. Mrs. C asked students to draw arrows between the frames describing what they changed and why they made that change from one trial to the next.

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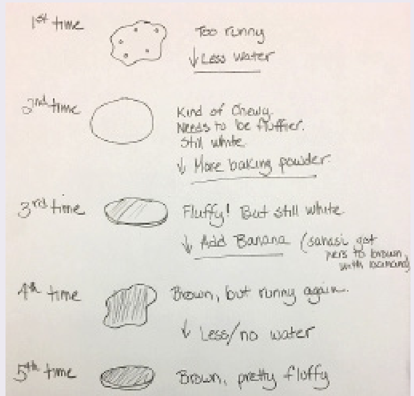
Figure 4.23. Student's Storyboard Documenting Recipe Refinement



[Long description of Figure 4.23.]

After they finished writing, the students compared all of the recipes and picked the best three that they wanted to try to repeat as a class (3–5-ETS1-2). During the discussion, students had to **support their choice with evidence [SEP-7]** from the recorded results. Mrs. C cooked the pancakes and one recipe turned out very different than on the previous day. Students discussed in groups why they think it might have been different and came up with ideas about mistakes in measuring ingredients and mistakes in recording the results. Mrs. C emphasized that careful measurements and documentation are essential skills that allow professional engineers to reproduce their solutions and share them with others.

Mrs. C wanted students to discuss how pancake cooking relates to chemical reactions. She reminded students that a chemical reaction could change the way substances look, smell, feel, or taste. She told them that there were at least three key chemical reactions that they could identify from the ingredient mixing and pancake cooking lessons. She instructed students to work in groups to fill in a table describing three different chemical reactions and how they recognize them (table 4.5).

Table 4.5 Chemical Reactions in Pancakes

blank	Evidence for chemical reaction	Which ingredients reacted?	How did you determine which ingredients reacted?
1	Batter consistency/texture changes	Flour & Water	Happened when we combined flour & water alone in Lesson 3 (the texture change is more dramatic in wheat flour than oat flour).
2	"Fluffing": Bubbles form in batter (and more bubbles form when temperature goes up).	Baking powder & Water	Baking powder fizzed when mixed with water in Lesson 3.
3	"Browning": Unusual color change on outside of pancakes.	Banana & ???	Only happened when we added banana.

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Vignette Debrief

SEPs. Students performed a complete engineering design process that employed a wide range of SEPs. They began by **defining the problem [SEP-1]** as they developed criteria for making the perfect pancake (3–5-ETS1-1). They **conducted investigations [SEP-3]** into what happened when they mixed the available ingredients and again when they cooked their pancakes and recorded the results. They **asked a question [SEP-1]** at the end of day 2 when they discovered that all their pancakes were white: "What are we missing?" This question motivated a change. They briefly engaged in **arguments supported by evidence [SEP-7]** when they worked with teammates to select proportions to test on days 3 and 4, though this practice was not a major focus of the vignette. They iteratively **designed a solution [SEP-6]** as they tried out different proportions of ingredients to hone in on the perfect combination (3–5-ETS1-2, 3–5-ETS1-3). The changes they made were based on a **mental model [SEP-2]** of the chemical system and how each ingredient affected the system's behavior. They **analyzed and interpreted their data [SEP-4]** by reflecting on how their design changed from iteration to iteration on day 4. Teachers could extend the lesson to include more **mathematical thinking [SEP-5]** by having students graph pancake thickness versus amount of water, or help them **communicate their findings [SEP-8]** by creating a cookbook that also explained the science behind pancakes.

DCIs. By discussing the physical properties of the raw ingredients, the batter, and the cooked pancakes, students could gain a better understanding of the structure and properties of matter (PS1.A). The table on day 4 makes an explicit tie to chemical reactions (PS1.B). PS1.B does not occur in the foundation box for 5-PS1-4 in CA NGSS but is a focus in the middle grades (MS-PS1-2). The motivation for including it here is that explicit instruction about the observable features of chemical reactions draws attention to the types of changes that can occur in substances. However, the discussion of chemical reactions should be limited to observations with the naked eye or other senses. In the middle grades, students learn to relate these observable changes to a model of interacting molecules, but that discussion is not part of fifth grade in the CA NGSS.

CCCs. The CCCs helped draw students' attention to the physical processes at work. There was major emphasis on **scale, proportion and quantity [CCC 3]** throughout the ingredient exploration. Students thought about their recipe as a chemical **system [CCC-4]** that had components (ingredients) and energy input (heat from the griddle). They adjusted the amount of each ingredient, which **caused different effects [CCC-2]** on the pancake system (including the system properties of how it looks and tastes). The entire lesson sequence could be thought of as one large investigation into how the mixing of substances can cause changes that create a new substance (5-PS1-4).

CA CCSS Connections to English Language Arts and Mathematics. Throughout the lesson sequence students participated in collaborative conversations with their classmates to engineer the perfect pancake (SL.5.1a-d). This process called for students to measure and combine various ingredients and carefully record these measurements (5.MD.3-4). Through trial and error the students combined the different ingredients in different quantities until they create the perfect pancake.

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Resources:

Lesson plans with further guidance are available at https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link14

Sources:

Pictures and figures courtesy of Holliston Coleman and Matthew d'Alessio, California State University, Northridge.

IS2

Grade Five Instructional Segment 2: From Matter to Organisms

Prior to reaching grade five, students have developed understanding of the DCIs that all animals need food in order to live and grow; that they obtain their food from plants or from other animals; and that plants need air, water, and light to live and grow. Now, students tie all these ideas together with a **model [SEP 2]** that describes how **energy and matter flow [CCC-5]** within a **system [CCC-4]**. They trace matter from nonliving sources (water and air), to plants, animals, decomposers, and back again to plants. They also use their models and look for evidence to describe how **energy flows [CCC-5]** from the Sun to plants to animals.

GRADE FIVE INSTRUCTIONAL SEGMENT 2: FROM MATTER TO ORGANISMS

Guiding Questions

- What matter do plants need to grow?
- How does matter move within an ecosystem?
- How does energy move within an ecosystem?

Performance Expectations

Students who demonstrate understanding can do the following:

5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water. [Clarification Statement: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.]

5-LS2-1. Develop a model to describe the movement of matter among plants, animals decomposers, and the environment. [Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [*Assessment Boundary: Assessment does not include molecular explanations.*]

5-PS3-1. Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the Sun. [Clarification Statement: Examples of models could include diagrams, and flow charts.]