Integrated STEM Unit Planner

Grade 5 Science

Make a Pancake

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PreK-12STEM
Community Training & Assistance Center (CTAC)
Tracy Unified School District

About the Integrated STEM Units

The integrated STEM units are a product of the partnership between Community Training and Assistance Center (CTAC) and Tracy Unified School District (TUSD) in California, funded in part through the Education Innovation and Research (EIR) program of the U.S. Department of Education in 2018. Teacher leaders came together to develop innovative units that align to STEM standards for student learning—namely the Next Generation Science Standards (NGSS) for California Public Schools, the Computer Science Content Standards derived from the national K-12 Computer Science Framework, and the California Common Core State Standards.

Each integrated unit brings together the following:

- an engineering design challenge
- one or more computational artifacts
- core science and math content
- language building opportunities
- engagement supports

Students in each grade level, pre-kindergarten through twelve, engage with the unit for about one or two months as part of their required coursework. The units are integrated and self-contained as a means to provide all students with equitable STEM experiences.

About the Partners

Community Training and Assistance Center (CTAC) is a national not-for-profit organization with a demonstrated record of success in the fields of education and community development. Tracy Unified School District, located in California's Central Valley, serves approximately 15,000 students. Fifty leading teachers from the district contributed to the development of the units. Computer Science integrations resulted with support from the San Joaquin County Office of Education and Bootstrap of Brown University.

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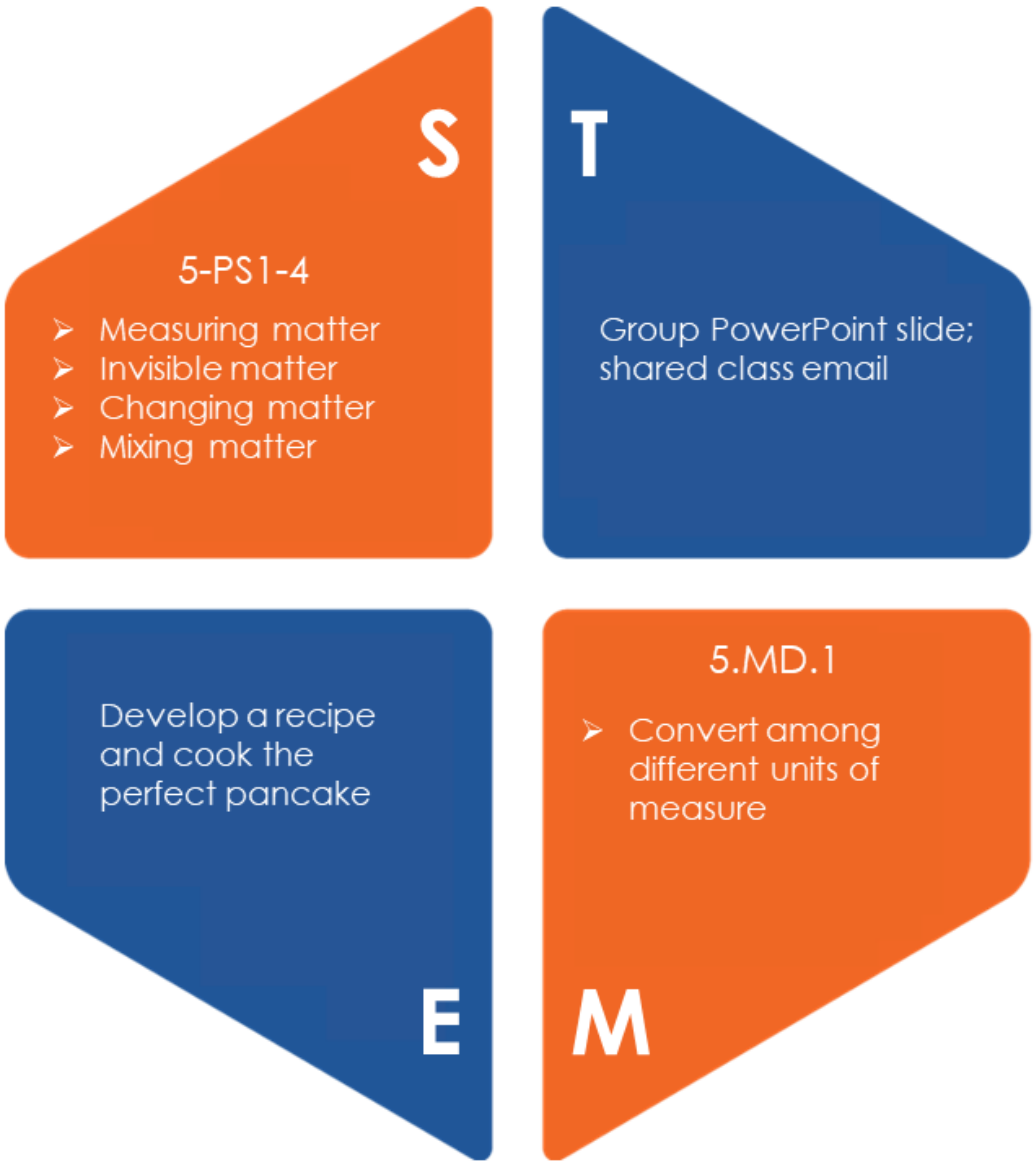
Contents

Big Picture

Unit Emblem



Focal Standard

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.]

Overview

Sequence 1: Teachers engage students with an anchoring phenomenon by showing a picture of different chocolate chip cookies followed by a discussion about what differences they observe, questioning possible reasons for the cookies being different, and considering what materials could have made those differences. This phenomenon relates to the driving essential question of the unit: How does matter interact and affect our everyday lives? Students will continue to answer this question and refine their knowledge throughout the sequence of this unit.

Students will learn about various ways to measure matter and how properties observed can be used to identify materials. The design challenge will be introduced which is to determine how to make the perfect pancake. Students will be shown a picture of different kinds of pancakes (Framework resource link here) (d'Alessio, 2015[i]). Remind students of the picture they originally discussed at the beginning of the unit then introduce the challenge. Let students brainstorm initial ways to meet the challenge in their sense-making notebooks. Students ***ask*** questions about the challenge including: What happens when we mix materials? What does a perfect pancake look like? What are the optimal proportions of the ingredients?

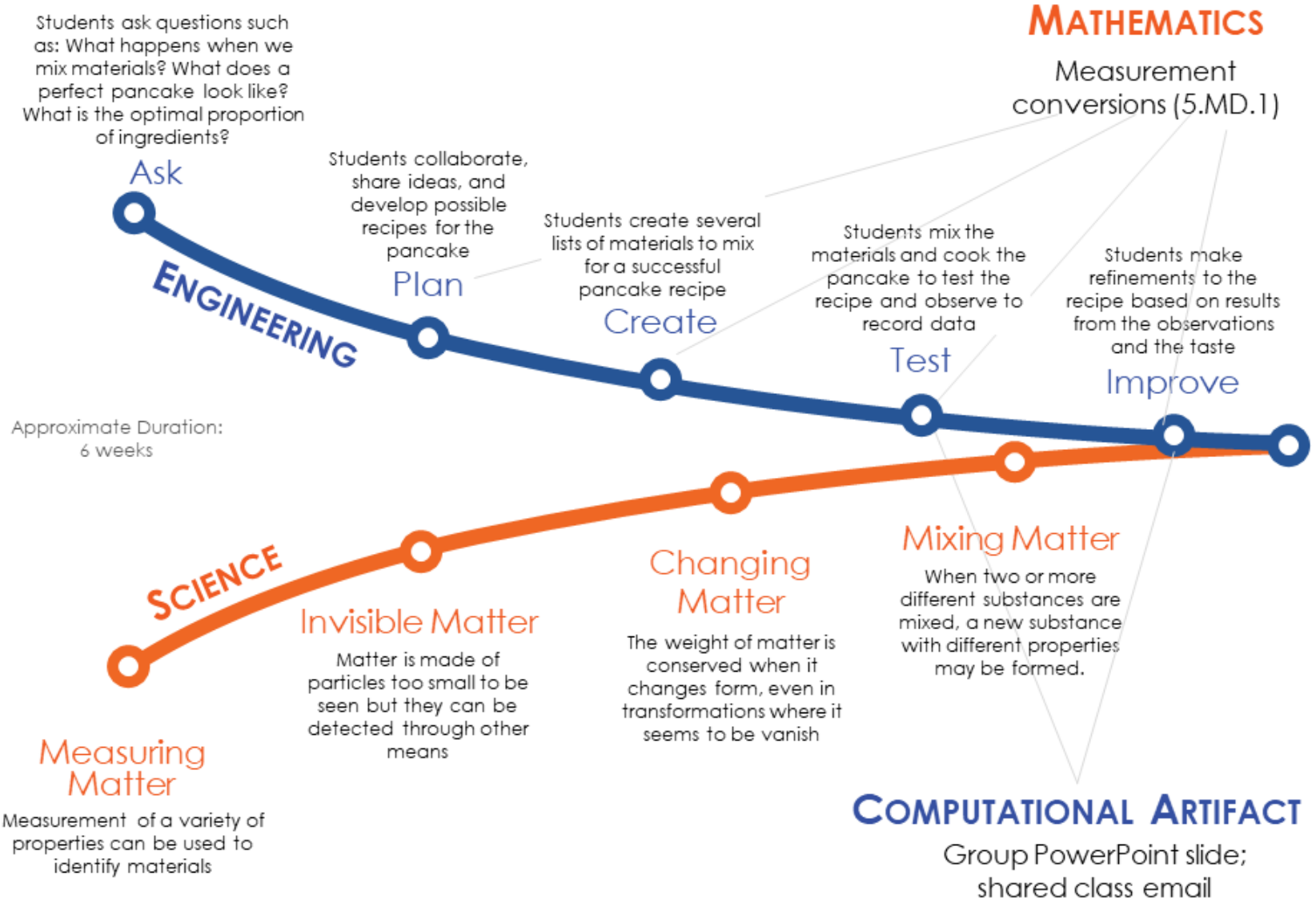
Sequence 2: Students will learn about invisible matter, particles that make up matter but may be too small to detect with the human eye. Students will experience various demonstrations of this concept. At the same time, students will begin to ***plan*** their pancake. Students will collaborate, share ideas, and develop possible recipes for the pancake, listing materials needed.

Sequence 3: Students will learn about changing matter through heating, cooking and mixing ingredients and develop an understanding of the conservation of weight. Students will work in groups to ***create*** the pancake, mixing the materials they selected, cooking the pancake.

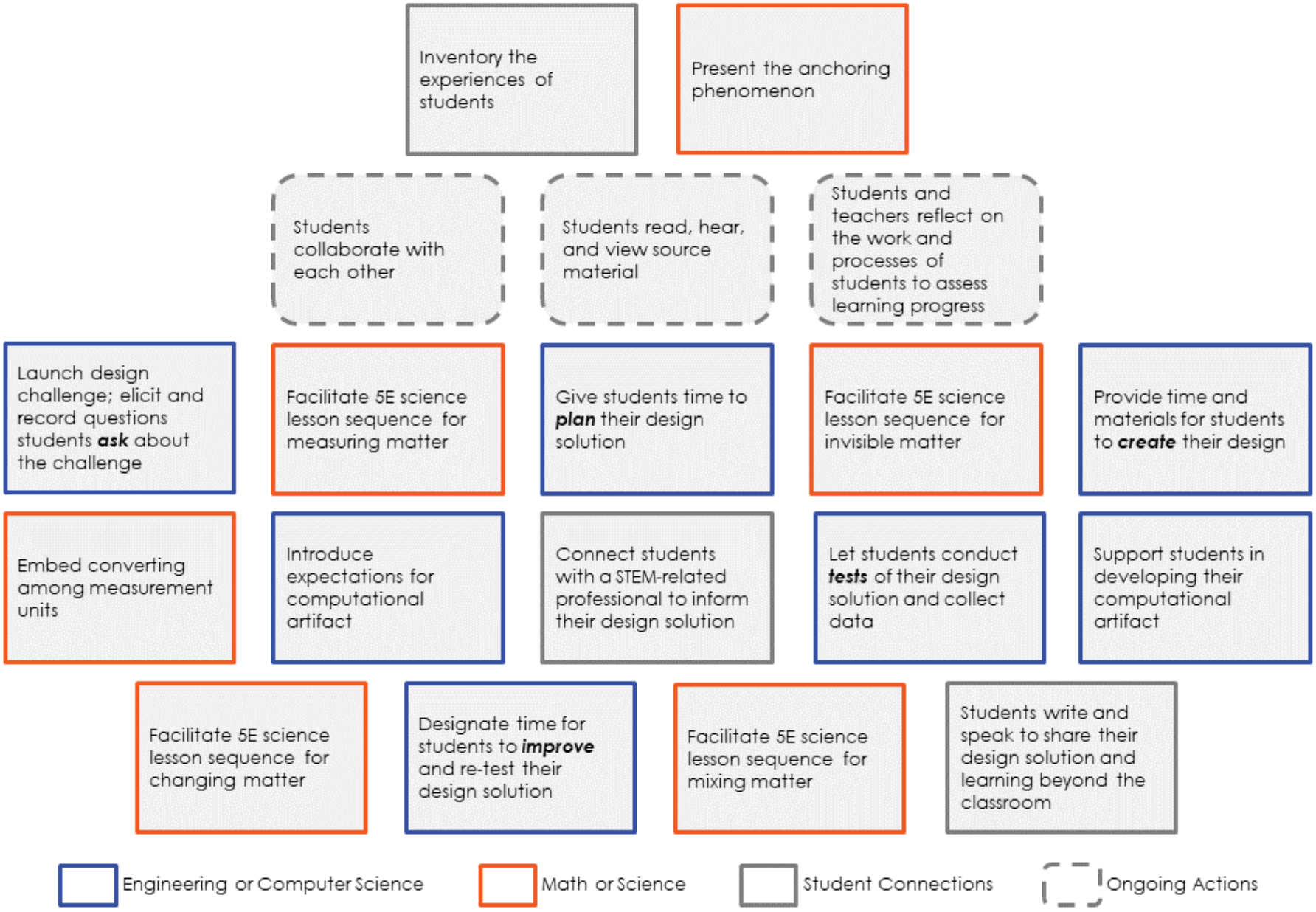
Sequence 4: Students then begin to ***test*** their pancakes, collecting data to determine how close their pancake represents the "perfect" pancake.

Sequence 5: Students reflect on their data to ***improve*** the pancake. Students make refinements to the recipe based on results from the observations and the taste and then conduct follow-up tests on their improved plan. Students will complete a power point slide about the design and improvement process, sharing details of the process they followed in their oral presentations.

Integrated Unit Storyline



Integrated Unit Wayfinder



STEM Dive

Engineering

Design Challenge: Develop a recipe and cook the perfect pancake.

Type of Engineering: Chemical Engineering

The Engineering Design Process (EDP) and Engineering Standards

EDP Step	Standard and Grade Band End Points from the *Framework*
Ask *Students ask questions such as: What happens when we mix materials? What does a perfect pancake look like? What is the optimal proportion of ingredients??*	**3-5-ETS1-1.** Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)
Plan *Students collaborate, share ideas, and develop possible recipes for the pancake*	**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. • Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) • At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)
Create *Students create several lists of materials to mix for a successful pancake recipe*	
Test *Students mix the materials and cook the pancake to test the recipe and observe to record data*	**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. • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)
Improve *Students make refinements to the recipe based on results from the observations and the taste*	

Computer Science (Technology)

Computer Science Integrations

Description of Student Engagement

Each class will develop a shared Power Point with each group using one slide to present their pancake and recipe. On the slide, students will include a picture of their batter, a picture of the pancake, ingredients used, and a chemical reaction explanation. Teachers will share this Power Point with two other teachers at different sites. As a whole class, students will evaluate each Power Point and help draft a reply email with questions, comments, or suggestions for recipe variation.

Computational Artifact

Definition: Anything created by a human using a computational thinking process and a computing device. A computational artifact can be, but is not limited to, a program, image, audio, video, presentation, or web page file. (Source: College Board, 2016)

- Microsoft PowerPoint presentation for the class with each group slide containing:
    - pictures of the group's batter and pancake
    - a listing of ingredients and explanation of what happened to the pancake when cooked
- Shared class email reply to another class commenting on their similar Microsoft PowerPoint

Hardware

Definition: The physical components that make up a computing system, computer, or computing device. (Source: MDESE, 2016)

- Computer

Software (includes programs, applications, websites, etc.)

Definition: Programs that run on a computing system, computer, or other computing device. (Source: k12cs.org)

- Microsoft PowerPoint

Standards

- **3-5.DA.8** Organize and present collected data visually to highlight relationships and support a claim.
- **3-5.AP.10** Compare and refine multiple algorithms for the same task and determine which is the most appropriate.
- **3-5.AP.13** Decompose problems into smaller, manageable tasks which may themselves be decomposed.
- **3-5.AP.18** Perform different roles when collaborating with peers during the design, implementation, and review stages of program development.

Science

Focal Standard

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.]

Related Content Standards

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*.]

Anchoring Phenomenon

Teachers engage students with an anchoring phenomenon by showing different kinds of cookies (one potential video is here) (Food Insider, 2019[ii]).

Content Outline

Below is a content outline for the science content in this unit. It includes the key concepts within the unit along with an approximate number of days it would take to facilitate a sufficient amount of student learning experiences. For each key concept, key learnings appear, which come from the grade band endpoints in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (source: https://www.nextgenscience.org/framework-k-12-science-education). The storyline begins with an anchoring phenomenon.

Key Concept	Key Learnings	# of Days
Measuring Matter	• Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.) (5.PS1.3.A: Structure and Properties of Matter)	7
Invisible Matter	• Matter of any type can be subdivided into particles that are too small to see, but even then, the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. (5.PS1.1.A: Structure and Properties of Matter)	7
Changing Matter	• The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. (5.PS1.1.A Structure and Properties of Matter) • No matter what reaction or change in properties occurs, the total weight of the substances does not change. (Boundary: Mass and weight are not distinguished at this grade level.) (5.PS1.1.B: Chemical Reactions	7
Mixing Matter	• When two or more different substances are mixed, a new substance with different properties may be formed.(5.PS1.4.A: Chemical Reactions)	7

Science and Engineering Practices	Crosscutting Concepts
1. Asking questions and defining problems **2. Developing and using models** **3. Planning and carrying out investigations** **4. Analyzing and interpreting data** **5. Using mathematics and computational thinking** **6. Constructing explanations and designing solutions** **7. Engaging in argument from evidence** 8. **Obtaining, evaluating, and communicating information**	1. Patterns **2. Cause and effect** **3. Scale, proportion, and quantity** 4. Systems and system models 5. Energy and matter 6. Structure and function 7. Stability and change

Note. Bolded items are called out specifically in the standards cluster for this unit.

Mathematics

Description of Student Engagement

Students measure ingredients for making their pancakes and convert from one measurement scale to another.

Standards for Mathematical Content

5.MD.1 Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.

Standards for Mathematical Practice

MP.1 Make sense of problems and persevere in solving them.

MP.2 Reason abstractly and quantitatively.

MP.3 Construct viable arguments and critique the reasoning of others.

MP.4 Model with mathematics.

MP.5 Use appropriate tools strategically.

MP.6 Attend to precision.

MP.7 Look for and make use of structure.

MP.8 Look for and express regularity in repeated reasoning.

Note. Bolded items are emphasized in this unit.

English Language Arts and Development

Reading Standard: Key Idea and Details

RI.5.2 Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.

Reading Standard: Integration of Knowledge and Ideas

RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

Writing Standard: Text Types and Purposes

W.5.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

- **W.5.2.A** Introduce a topic clearly, provide general observation and focus, and group related information logically; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension.
- **W.5.2.B** Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic.
- **W.5.2.C** Link ideas within and across categories of information using words, phrases, and clauses (e.g., in contrast, especially).
- **W.5.2.D** Use precise language and domain-specific vocabulary to inform about or explain the topic.
- **W.5.2.E** Provide a concluding statement or section related to the information or explanation presented.

Speaking and Listening Standard: Comprehension and Collaboration

SL.5.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 5 topics and texts*, building on others' ideas and expressing their own clearly.

Speaking and Listening Standard: Presentation and Knowledge of Ideas

SL.5.4 Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

Unit Vocabulary

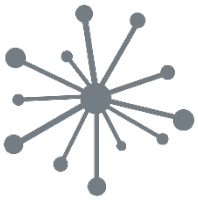
The following terms reflect the core vocabulary students should understand and use in this unit.

- **boiling point**: Boiling point is the temperature at which a liquid boils (and turns into a vapor). (Source: https://www.merriam-webster.com/dictionary/boiling%20point)
- **chemical reaction**: A chemical reaction refers to a change in a chemical. More generally, a chemical reaction can be understood as the process by which one or more substances change to produce one or more different substances. (Sourced from NRC[1]: https://bit.ly/3BYYCUC)
- **clarity**: Water clarity, most simply stated, is a measurement of how "see through" water is. But, there's a lot more to it than that. Many factors can influence water clarity, such as the turbidity, algae abundance, the presence of pollutants, and more. Water clarity generally decreases as the suspended load increases. Muddy water is harder to see through. (Sourced from USGS[2]: https://on.doi.gov/3jW1jQl)
- **condensation**: Condensation is the conversion of a vapor to a liquid (as by cooling). (Source: https://www.merriam-webster.com/dictionary/condensation)
- **conductivity**: Conductivity is the ability to move heat or electricity from one place to another. (Source: https://www.merriam-webster.com/dictionary/conductivity)
- **conservation**: When you have a closed system, where matter cannot escape, physical or chemical changes of the matter does not change the volume of matter. For example, when ingredients are mixed, they may look different, but the amount of matter has not changed.
- **dissolve**: Substances are dissolved when a substances is mixed with a liquid and become part of the liquid. (Source: adapted from: https://www.merriam-webster.com/dictionary/dissolve)
- **evaporate**: Evaporation means to change from a liquid into a gas. (Source: https://www.merriam-webster.com/dictionary/evaporate)
- **freezing point**: The freezing point is the temperature at which a liquid solidifies. (Source: https://www.merriam-webster.com/dictionary/freezing%20point)
- **ingredient**: An ingredient is something that enters into a compound or is a component part of any combination or mixture. (Source: https://www.merriam-webster.com/dictionary/ingredient)

[1] NRC = U.S. Nuclear Regulatory Commission
[2] USGS = U.S. Geological Survey

- **mass**: Mass is the amount of matter in an object.
- **matter**: Matter is the substance of which a physical object is composed. (Source: https://www.merriam-webster.com/dictionary/matter)
- **particle**: A particle is a relatively small or the smallest discrete portion or amount of something. (Source: https://www.merriam-webster.com/dictionary/particle)
- **phenomenon**: A phenomenon is something (such as an interesting fact or event) that can be observed and studied and that typically is unusual or difficult to understand or explain fully. (Source: https://www.merriam-webster.com/dictionary/phenomenon)
- **pollutant**: A pollutant is a chemical or biological substance in a form that can be incorporated into, onto, or be ingested by aquatic [or terrestrial] organisms, consumers of aquatic organisms, or users of the aquatic [or terrestrial] environment. (Adapted from the EPA: https://bit.ly/3njV1N8). Pollutants be harmful to the air, water, and soil.
- **properties**: A property is a quality or trait belonging and especially peculiar to an individual or thing. (Source: https://www.merriam-webster.com/dictionary/property)
- **proportion**: A proportion is the size, number, or amount of one thing or group of things as compared to that of another thing or group of things. (Source: https://www.merriam-webster.com/dictionary/proportion)
- **prototype**: A prototype is an original model on which something is patterned. Also it can be a first full-scale and usually functional form of a new type or design of a construction (such as an airplane). (Source: https://www.merriam-webster.com/dictionary/prototype)
- **recipe**: A recipe is a set of instructions for making something from various ingredients. (Source: https://www.merriam-webster.com/dictionary/recipe)
- **reflectivity**: Reflectivity is the fraction of radiant energy that is reflected from a surface; or the ability to reflect beams or rays. (Sourced from NASA: https://go.nasa.gov/2X9964A)
- **solubility**: Solubility is the amount of a substance that will dissolve in a given amount of another substance. (Source: https://www.merriam-webster.com/dictionary/solubility)
- **subjective**: Subjective means peculiar to a particular individual or modified or affected by personal views, experience, or background. (Source: https://www.merriam-webster.com/dictionary/subjective)
- **substance**: A substance is a material of a particular kind. (Source: https://www.merriam-webster.com/dictionary/substance)

Assessment Tools



Student Experience Inventory

Teachers can use the following prompts with students prior to the beginning of the unit or early in the unit in order to learn about students' experiences that relate to the unit. Teachers can make informed instructional decisions based on this learning, enabling tailored opportunities for students to make their own meaning.

Student Prompts

1. Think about a blowing up a balloon. (You may want to have one handy to have the student or yourself demonstrate.) What do you notice as it is blown up?

2. What kinds of things have you mixed together before? What did you notice? (Additional prompts: What did you mix? What did it look and feel like before and after you mixed it?)

3. What kinds of things have you seen get hotter (or colder)? What did you notice?

4. What kinds of things are cooked in your home? How are they prepared?

Aligned Learnings

1. Responses to this item provide insight into students' experiences with matter (air) made of particles too small to be seen. 5-PS1-1

2. Responses to this item provide insight into students' experiences with mixtures and properties of mixtures. 5-PS1-2, 5-PS1-3, 5-PS1-4

3. Responses to this item provide insight into students' experiences with heating and cooling substances and their properties. 5-PS1-2, 5-PS1-3

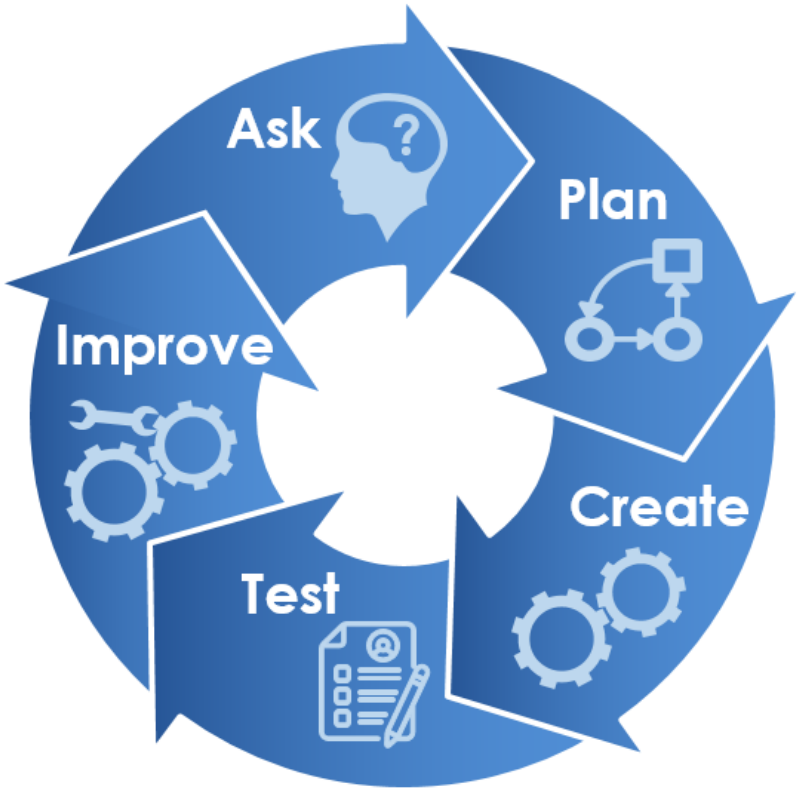
4. Responses to this item provide insight into students' experiences with culinary mixtures. 5-PS1-4

Student Self-Assessment of Engineering

Improve:
Here is what would make my design better and why…

Ask:
Here is what I am wondering about before I plan my design…

Plan:
Here are my design ideas for the project…



Test:
Here are the data I collected…

Create:
Here is what I think about what I made compared to what I planned, and here is what I think will happen when I test it…

I am doing the work of a chemical engineer.

One-Point Design Challenge Rubric

Criteria serve as a primary reference point throughout the engineering design process. Teachers use the criteria **to communicate expectations** and **to guide students**. With teacher guidance, students use the criteria to inform and reflect on their work.

Approaches Expectations *Notes on how to improve the project*	**Meets Expectations** *Criteria indicating success*	**Exceeds Expectations** *Notes on how project goes beyond expectations*
	Engineering Students participate in the 5-part engineering design process, use data, and make thoughtful improvements to their design. (3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3)	
	Computer Science The computational artifact shows student success in using features of PowerPoint. (3-5.DA.8, 3-5.AP.10, 3-5.AP.13, 3-5.AP.18)	
	Collaboration Students contribute and support others with honesty and kindness (including feedback given and received on shared PowerPoint presentations) (SL.5.1)	
	Communication Students speak and write using academic vocabulary to share thoughts (W.5.2.A-E) and read and listen to learn from others (SL.5.4)	
	Science Use knowledge of properties and chemical reactions to choose ingredients and create a successful pancake. (5-PS1-4)	

Engagement

Community and Career Connections

During the unit, students engage with STEM professionals who can inform students' work at some point during the engineering design process. The interaction with STEM professionals serves a few purposes:

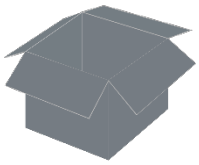
- Expose students to STEM as it applies in various careers
- Enrich student learning through collaborating with STEM professionals
- Help students see themselves doing the actual work of STEM

Below are a few potential STEM-related professionals that align to one of California's 15 industry sectors for Career and Technical Education:

- **Chef, Pastry Chef, Baker** (Hospitality, Tourism and Recreation)
- **Cement Mixer** (Building and Construction Trades)
- **Chemist** (Engineering and Architecture)

The interactive experience will ideally be co-constructed by the teacher and professional. In coordinating with the professional, a few questions appear below that can be used to guide the planning and live interaction with students:

- **Chef, Pastry Chef, Baker** (Hospitality, Tourism and Recreation)
  - What kinds of dishes, pastries or breads are made in your bakery?
  - How important is measurement in what you do?
  - How can you adjust a recipe for one small cake, for instance, to a large cake or a number of cakes to be made at once?
  - What does a typical day on the job look like?
  - What is one problem you are currently facing in your day-to-day work?
- **Cement Mixer** (Building and Construction Trades)
  - Are there different mixtures of materials that go into cement for different purposes (such as paving a driveway, building a foundation of a house, or making a wall)?
  - Are there differences in the outcome depending on how you pour the cement?
  - Does temperature affect the quality of the cement?
  - On what types of buildings do you typically work?
- **Chemist** (Engineering and Architecture)
  - What kinds of chemicals do you work with and what is being made with those chemicals?
  - What tools do you use?
  - What kind of substances to you need to create in your job? How important is measurement to your job? What would happen is you mis-measure?



Materials List

The items in the materials list below reflect total quantities for a class of 32 students, allowing for 8 groups of 4 students.

Permanent Equipment (classroom totals):

- ☐ 8 griddles
- ☐ 32 spatulas
- ☐ 32 rulers
- ☐ 32 scoops (15ml/15cc)

Consumable Equipment (classroom totals):

- ☐ 10 lbs. of Flour A (wheat flour if available)
- ☐ 10 lbs. of Flour B (another flour for comparison, such as white flour)
- ☐ 3 cups of baking soda
- ☐ 3 cups of sugar
- ☐ 8 cans of baking spray
- ☐ 32 paper cups (16 oz.)
- ☐ 32 toothpicks
- ☐ 32 popsicle sticks
- ☐ 32 small paper plates

Distance Learning Modifications

In distance learning, the design challenge will be conducted by students individually at home. Student collaboration will need to occur remotely with a modified materials list. **For this challenge, ensure students have adult supervision when cooking the pancakes.**

Modified Materials List (student totals):

- ☐ 1 cooking surface (e.g., griddle or hot plate) **(adult supervision required)**
- ☐ 1 scoop
- ☐ 1 spatula
- ☐ 1 ruler
- ☐ 1 cup of Flour A (wheat flour if available)
- ☐ 1 cup of Flour B (another flour for comparison, such as white flour)
- ☐ 4 teaspoons of baking soda
- ☐ 4 teaspoons of sugar
- ☐ 1 can of baking spray
- ☐ 2 quart size plastic bags
- ☐ 2 snack size plastic bags
- ☐ 1 paper cup (16 oz.)
- ☐ 1 toothpick
- ☐ 2 popsicle sticks
- ☐ 1 paper plate

Endnotes

[i] D'Alessio, M. (2015, October 3). *Pancake engineering presentation.* *https://mycsun.app.box.com/s/dz8ka73vppalszseej9gvbbki01xrwta/file/39302851809*

[ii] Food Insider. (2019, September 26). *What cookies look like around the world*. YouTube. https://www.youtube.com/watch?v=s41T6KWQIhQ