Integrated STEM Unit Planner

Pre-Kindergarten and Transitional Kindergarten Science
Stand Up a Structure

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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

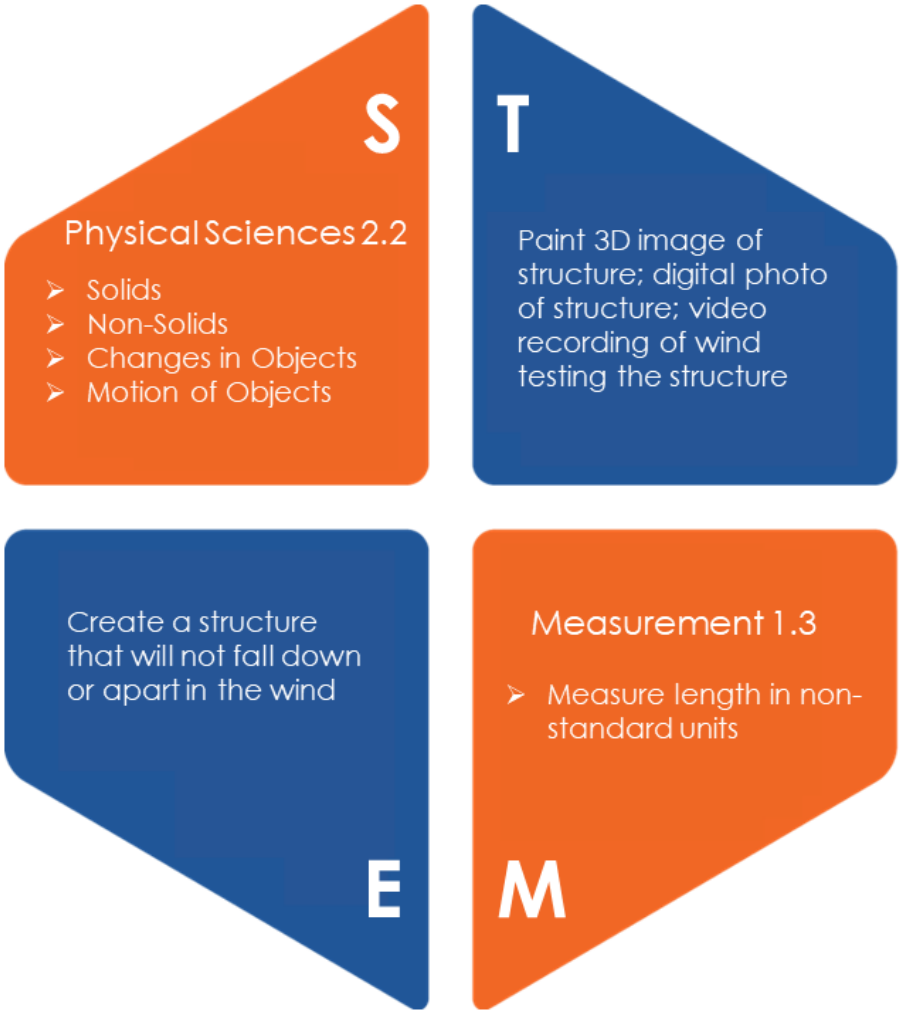
Community Training and Assistance Center (CTAC) is a national not-for-profit organization with a demonstrated record of success in the fields of education and community development. Tracy Unified School District, located in California's Central Valley, serves approximately 15,000 students. Fifty leading 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.

Terms of Use

Contents

Big Picture

Unit Emblem



Focal Standard

Physical Science	
2.0 Changes in Nonliving Objects and Materials	
At around 48 months of age	*At around 60 months of age*
2.2 Observe and describe the motion of objects (in terms of speed, direction, the ways things move), and explore the effect of own actions (e.g., pushing pulling, rolling, dropping) on making objects move.	**2.2 Demonstrate an increased ability to observe and describe in greater detail the motion of objects (in terms of speed, direction, the ways things move), and to explore the effect of own actions on the motion of objects, including changes in speed and direction.**

Overview

Sequence 1: Teachers engage students with an anchoring phenomenon by showing a video of damage to structures caused by a storm. YouTube has a number of videos of storm damage from various locations around the United States. Teachers will help students build an inquiry anchor chart (I notice, I think, I wonder) to review what they have seen. They will begin to consider the driving essential question: How does wind affect us and our buildings?

Early lessons will focus on the properties of solids and how they can be classified based on their characteristics. Teachers will introduce the design challenge: To build a structure that will not fall down or apart in the wind. Students will begin to ***ask*** questions like: What kinds of materials can we use? How tall does it need to be? How big does it need to be?

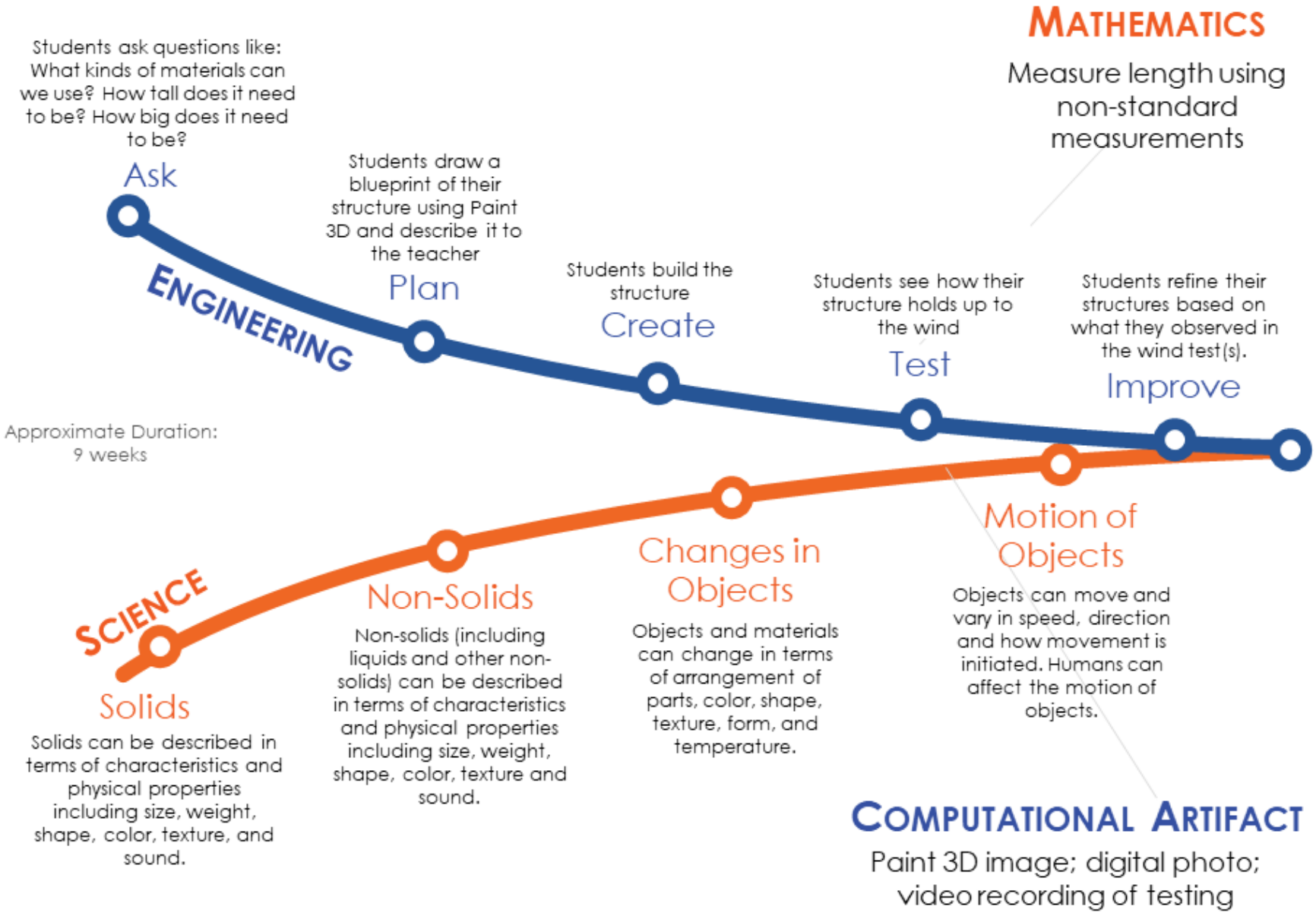
Sequence 2: Students will learn about the properties of non-solids and will begin to consider how they can use what they have learned to ***plan*** their model, making an initial blueprint in Paint 3D.

Sequence 3: Students will consider the materials available and begin to ***create*** their structure. They will learn about how objects can change in arrangement of parts, form, color, shape, texture, and form based on changes in their environment.

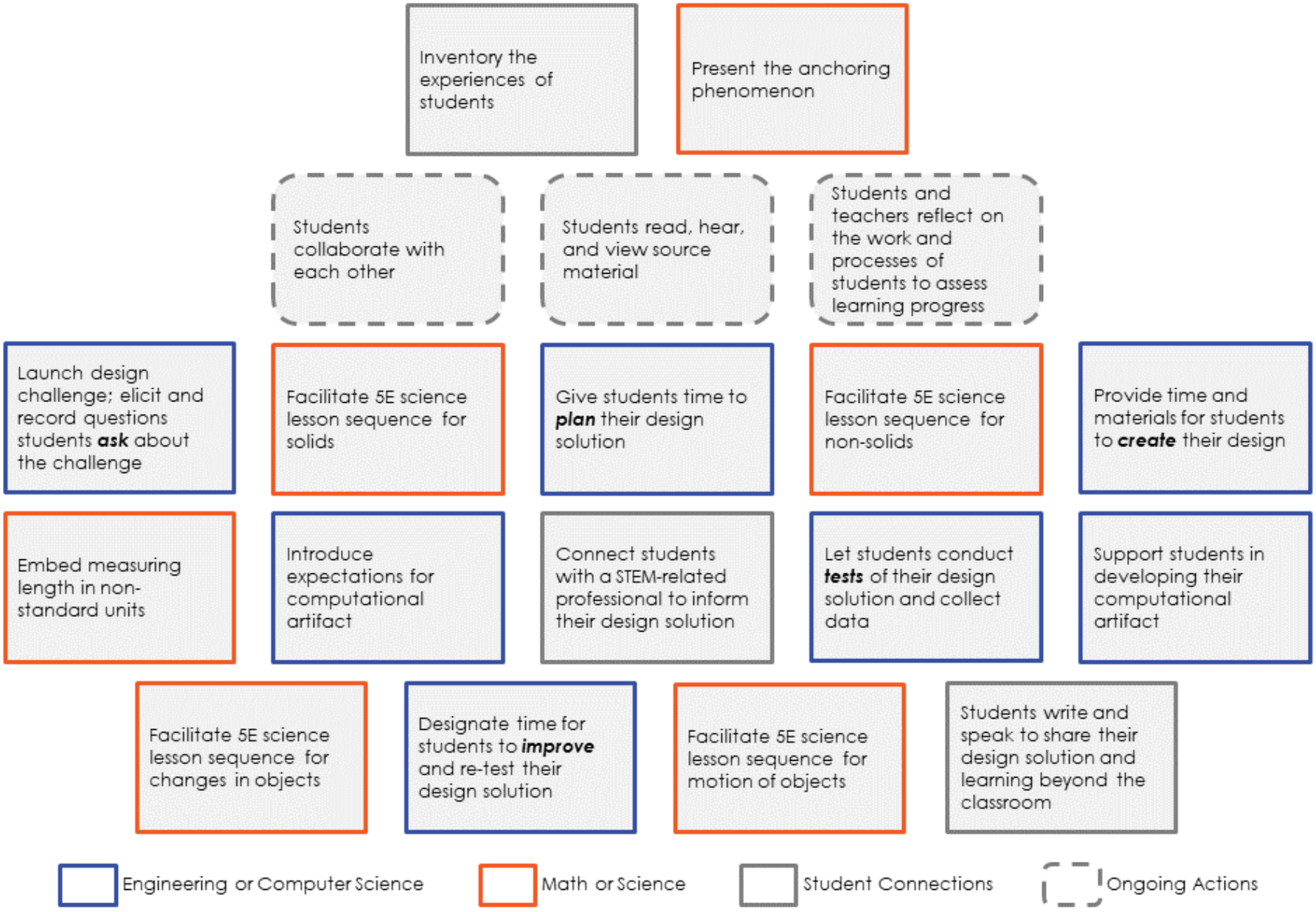
Sequence 4: Students will ***test*** the effectiveness of their structure by exposing it to a wind source. They will make observations about how effective their structure was at surviving the wind. This will be augmented by learning about how objects and materials can be moved, with outcomes varying in speed, direction, and initial cause of the movement.

Sequence 5: Students will reflect on what they learned from their test and observations of others and will revise the plan to ***improve*** their structure.

Integrated Unit Storyline



Integrated Unit Wayfinder



STEM Dive

Engineering

Design Challenge: Create a structure that will not fall down or apart in the wind.

Type of Engineering: Architectural Engineering

The Engineering Design Process (EDP) and Engineering Standards

EDP Step	Standard and Grade Band End Points from the *Framework*
Ask *What kinds of materials can we use? How tall does it need to be? How big does it need to be?*	**K-2-ETS1-1.** Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool. • A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1) • Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) • Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)
Plan *Students draw a blueprint of their structure using Paint 3D and describe it to the teacher.*	**K-2-ETS1-2.** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem. • Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2)
Create *Students build the structure.*	
Test *Students see how their structure holds up to the wind.*	**K-2-ETS1-3.** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs. • Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)
Improve *Students refine their structures based on what they observed in the wind test(s).*	

Computer Science (Technology)

Computer Science Integrations

Description of Student Engagement

1. Students will take a digital photo of their structure.
2. Students will make a Microsoft Paint 3D image of their structure.
3. Students will make a video recording of the wind trials testing their structure.

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)

- Digital photo
- Microsoft Paint 3D publication
- Video recording

Hardware

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

- Computer with camera and video recorder

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

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

- Microsoft Paint 3D
- Camera and video editing software

Standards

- **K-2.DA.7** Store, copy, search, retrieve, modify, and delete information using a computing device, and define the information stored as data.
- **K-2.DA.8** Collect and present data in various visual formats.
- **K-2.DA.9** Identify and describe patterns in data visualizations, such as charts or graphs, to make predictions.

Foundations in Science

Focal Standard

Physical Science	
2.0 Changes in Nonliving Objects and Materials	
At around 48 months of age	*At around 60 months of age*
2.2 Observe and describe the motion of objects (in terms of speed, direction, the ways things move), and explore the effect of own actions (e.g., pushing pulling, rolling, dropping) on making objects move.	**2.2 Demonstrate an increased ability to observe and describe in greater detail the motion of objects (in terms of speed, direction, the ways things move), and to explore the effect of own actions on the motion of objects, including changes in speed and direction.**

Related Content Standards

Scientific Inquiry	
1.0 Observation and Investigation	
At around 48 months of age	*At around 60 months of age*
1.1 Demonstrate curiosity and raise simple questions about objects and events in their environment.	1.1 Demonstrate curiosity and an increased ability to raise questions about objects and events in their environment.
1.3 Begin to identify and use, with adult support, some observation and measurement tools.	1.3 Identify and use a greater variety of observation and measurement tools. May spontaneously use an appropriate tool, though may still need adult support.
1.4 Compare and contrast objects and events and begin to describe similarities and differences.	1.4 Compare and contrast objects and events and describe similarities and differences in greater detail.
1.5 Make predictions and check them, with adult support, through concrete experiences.	1.5 Demonstrates an increased ability to make predictions and check them (e.g., may make more complex predictions, offer ways to test predictions, and discuss why predictions were correct or incorrect).
1.6 Make inferences and form generalizations based on evidence.	1.6 Demonstrate an increased ability to make inferences and form generalizations based on evidence.

2.0 Documentation and Communication	
2.1 Record observations or findings in various ways, with adult assistance, including pictures, words (dictated to adults), charts, journals, models, and photos.	2.1 Record information more regularly and in greater detail in various ways, with adult assistance, including pictures, words (dictated to adults), charts, journals, models, photos, or by tallying and graphing information.
2.2 Share findings and explanations, which may be correct or incorrect, with or without adult prompting.	2.2 Share findings and explanations, which may be correct or incorrect, more spontaneously and with greater detail.
Physical Science	
1.0 Properties and Characteristics of Nonliving Objects and Materials	
1.1 Observe, investigate, and identify the characteristics and physical properties of objects and of solid and nonsolid materials (size, weight, shape, color, texture, and sound).	1.1 Demonstrate increased ability to observe, investigate, and describe in greater detail the characteristics and physical properties of objects and of solid and nonsolid materials (size, weight, shape, color, texture, and sound).
2.0 Changes in Nonliving Objects and Materials	
2.1 Demonstrate awareness that objects and materials can change; explore and describe changes in objects and materials (rearrangement of parts; change in color, shape, texture, temperature)	2.1 Demonstrate an increased awareness that objects and materials can change in various ways. Explore and describe in greater detail changes in objects and materials (rearrangement of parts; change in color, shape, texture, form, and temperature)
Earth Science	
2.0 Changes in the Earth	
2.3 Begin to notice the effects of weather and seasonal changes on their own lives and on plants and animals.	2.3 Demonstrate an increased ability to notice and describe the effects of weather and seasonal changes on their own lives and on plants and animals.

Anchoring Phenomenon

Teachers engage students with an anchoring phenomenon by showing a video of damage to structures caused by a storm.

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[1]	# of Days
Solids	• Demonstrate increased ability to observe, investigate, and describe in greater detail the characteristics and physical properties of objects and of solid and nonsolid materials (size, weight, shape, color, texture, and sound). (Physical Sciences 1.1)	10
Non-Solids	• Demonstrate increased ability to observe, investigate, and describe in greater detail the characteristics and physical properties of objects and of solid and nonsolid materials (size, weight, shape, color, texture, and sound). (Physical Sciences 1.1)	10
Changes in Objects	• Demonstrate an increased awareness that objects and materials can change in various ways. Explore and describe in greater detail changes in objects and materials (rearrangement of parts; change in color, shape, texture, form, and temperature) (Physical Sciences 2.1)	10
Motion of Objects	• Demonstrate an increased ability to observe and describe in greater detail the motion of objects (in terms of speed, direction, the ways things move), and to explore the effect of own actions on the motion of objects, including changes in speed and direction. (Physical Science 2.2)	10

[1] Key learnings are drawn from the standards designed for students who are 60-months of age. Address the parallel standards for younger students by reviewing the 48-months standards in the table above.

Foundations in Mathematics

Description of Student Engagement

Students will measure the length of their shelter using non-standard units.

Standards for Mathematical Content

Measurement	
1.0 Children begin to compare and order objects.	**1.0 Children expand their understanding of comparing, ordering, and measuring objects**
At around 48 months of age	*At around 60 months of age*
	1.3 Measure length using multiple duplicates of the same-size concrete units laid end to end.

Foundations in Language and Literacy

Listening and Speaking	
1.0 Language Use and Conventions	
At around 48 months of age	*At around 60 months of age*
1.2 Speak clearly enough to be understood by familiar adults and children.	1.2 Speak clearly enough to be understood by both familiar and unfamiliar adults and children.
2.0 Vocabulary	
2.3 Understand and use simple words that describe the relations between the objects.	2.3 Understand and use both simple and complex words that describe the relations between objects.
Reading	
2.0 Phonological Awareness	
	2.1 Orally blend and delete words and syllables without the support of pictures or objects.
	2.2 Orally blend the onsets, rimes, and phonemes of words and orally delete the onsets of words, with the support of pictures or objects.
Writing	
1.0 Writing Strategies	
1.2 Write using scribbles that are different from pictures.	1.2 Write letters or letter-like shapes to represent words or ideas.

Unit Vocabulary

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

- **air**: Air is the invisible mixture of odorless tasteless gases that surrounds the earth. (Source: https://www.merriam-webster.com/dictionary/air)
- **balance**: To balance means to be or make equal in weight, number, or amount. (Source: https://www.merriam-webster.com/dictionary/balance)
- **build**: To build means to make (something) by putting together parts or materials. (Source: https://www.merriam-webster.com/dictionary/build)
- **color**: Color is the perceived quality of an object such as red, blue, green, yellow, etc., that you see when you look at something. (Adapted from: https://www.merriam-webster.com/dictionary/color)
- **force**: A force is a pull or a push that causes an object to speed up or slow down in a particular direction. (Sourced from NASA: https://go.nasa.gov/3tJolxC)
- **liquid**: A liquid is a substance that is able to flow freely. (Source: https://www.merriam-webster.com/dictionary/liquid)
- **pull**: To pull describes the act of moving or trying to move something by holding it and bringing it toward you. (Source: https://www.merriam-webster.com/dictionary/pull)
- **push**: To push means to use force to move (someone or something) forward or away from you. (Source: https://www.merriam-webster.com/dictionary/push)
- **ramp**: A ramp is a sloping floor, walk, or roadway leading from one level to another. (Source: https://www.merriam-webster.com/dictionary/ramp)
- **shape**: Shape is the form or outline of an object. (Source: https://www.merriam-webster.com/dictionary/shape)
- **size**: Size is amount of space occupied by someone or something or how large or small someone or something is. (Source: https://www.merriam-webster.com/dictionary/size)
- **solid**: A solid is not hollow, or a gas or a liquid. (Adapted from: https://www.merriam-webster.com/dictionary/solid)

- **sound**: Sound is the sensation perceived by the sense of hearing. It is based on wave changes of pressure in the air. (Adapted from: https://www.merriam-webster.com/dictionary/sound)

- **speed**: Speed refers the rate of moving or doing [something]. (Source: https://www.merriam-webster.com/dictionary/speed)

- **structure**: A structure is something built or arranged in a definite way. (Source: https://www.merriam-webster.com/dictionary/structure)

- **temperature**: Temperature is degree [amount] of hotness or coldness as measured on a scale. (Source: https://www.merriam-webster.com/dictionary/temperature)

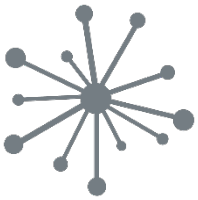
- **texture**: Texture refers to the way that something feels when you touch it. (Source: https://www.merriam-webster.com/dictionary/texture)

- **weight (light and heavy)**: The weight of something refers to the force with which a body is pulled toward the earth. Something that is light is easy to pick up and transport. Something that is heavy would require more effort to lift or to move. (Adapted from: https://www.merriam-webster.com/dictionary/weight)

- **wind**: Wind is the horizontal movement of air, transporting [heat] energy transferred from the earth's surface. (Adapted from NWS[2]: https://bit.ly/3AedLB1)

[2] NWS = National Weather Service

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. When you spend time outside, where are you and who is there with you?
2. What kinds of things do you like to play with during play time? (Additional prompts: Is there a favorite item you have? Why is it your favorite?)
3. What kinds of things have you seen move before? What happened?

Aligned Learnings

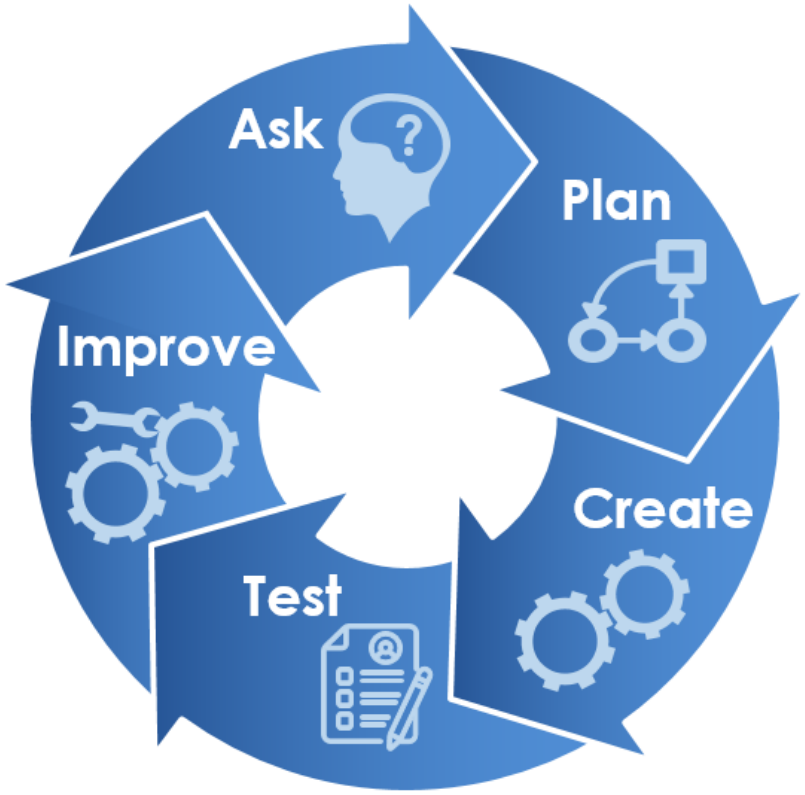
1. Responses to these items provide insight into students' experiences with their local environment.
2. Responses to these items provide insight into students' experiences with objects, materials, and their properties. 1.1, 2.1
3. Responses to these items provide insight into students' experiences with motion. 2.2

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 an architect.

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. (K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3)	
	Computer Science Students create a digital photo and Paint 3D sketch of their structure and create a video recording of the wind testing their structure. (K-2.DA.7, K-2.DA.8, K-2.DA.9)	
	Collaboration Students contribute and support others with honesty and kindness (Listening and Speaking1.2)	
	Communication Students speak and write about their ideas clearly using accurate vocabulary (Listening and Speaking 2.3, Writing 1.2). Students will share thoughts, read, and listen to learn from others. (LS.1.2)	
	Science Students will use observation and measurement tools to record finding and draw accurate inference and conclusions about their structures (Physical Sciences 2.2)	

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:

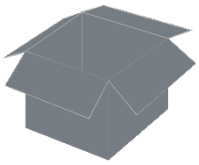
- Expose students to STEM as it applies in various careers
- Enrich student learning through collaborating with STEM professionals
- Help students see themselves doing the actual work of STEM

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

- **Bridge Designer** (Engineering and Architecture)
- **Hot Air Balloonist** (Hospitality, Tourism, and Recreation)
- **Commercial Building Construction Worker (**Building and Construction Trades)

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:

- **Bridge Designer** (Engineering and Architecture)
  - When you are getting ready to build a road or bridge, do you have to consider how windy the location will be, or are all bridges and roadways built in the same way?
  - What kinds of structures are built into bridges to make sure they are stable?
  - Is it always bad for a bridge to experience some movement in a heavy wind? Why or why not?
  - How does the height or the length of a bridge affect how you build it?
- **Hot Air Balloonist** (Hospitality, Tourism, and Recreation)
  - Why are balloons launched most frequently early in the morning or in late afternoon?
  - How does wind affect what you do with your balloon? Can it prevent you from launching a balloon?
  - Are the winds above the Earth different than those at the surface? If they are different, how are they different?
  - What would happen if you were in a balloon, everything was fine, but suddenly an unexpected thunderstorm appears? What would you do?
- **Commercial Building Construction Worker (**Building and Construction Trades)
  - Is wind something that you have to consider to keep yourself safe on a job site? What do you do to protect yourself if high winds were present?
  - Have you noticed a difference between winds on lower stories of buildings and winds at higher floors? How are they different and does that affect your safety precautions?
  - Are buildings constructed differently in places where high winds are common? What are some of these differences?
  - What are some other weather conditions that impact how you can do your work? Does weather ever prevent you from working on a building?



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:

- ☐ 1 fan (or other wind source)

Consumable Equipment:

- ☐ 1 box of 1000 craft sticks (120 per group)
- ☐ 320 pipe cleaners (40 per group)
- ☐ 8 rolls of clear tape (1 per group)

Consumable Equipment (from home or site as available):

- ☐ Recyclable materials (e.g. cardboard and other building materials)

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.

Modified Materials List:

- ☐ 10 craft sticks
- ☐ 10 pipe cleaners
- ☐ 1 roll of clear tape
- ☐ 10 sheets copy paper
- ☐ other trash (from home)