Integrated STEM Unit Planner

Grade 1 Science
Design a Light-Generating Device

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PreK-12 STEM
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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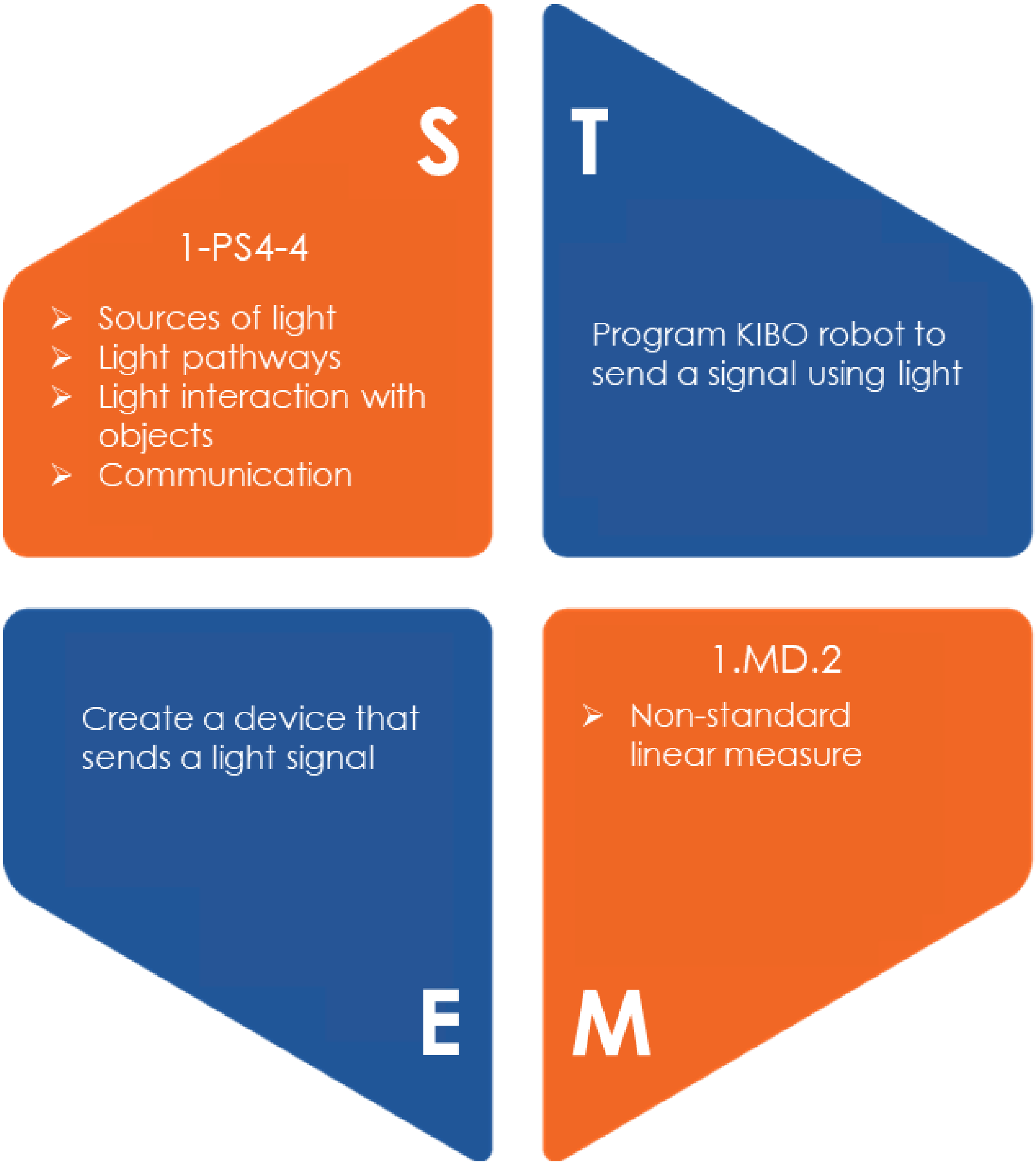
Big Picture

Unit Emblem



Focal Standard

1-PS4-4 Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.* [Clarification Statement: Examples of devices could include a light source to send signals, paper cup and string "telephones," and a pattern of drum beats.] [*Assessment Boundary: Assessment does not include technological details for how communication devices work.*]

Overview

Sequence 1: Teachers engage students with an anchoring phenomenon by have pairs of student play shadow tag in which one student's shadow needs to tag another person's shadow. Teachers group students in pairs, and have the pairs play shadow tag. Before returning to class, the pairs of students record the following in their own sense-making notebooks: (1) location of the partner, (2) location of the light source, and (3) direction of the partner's shadow. Students will draw and label their partners, the light source (sun), and the shadow.

Teachers facilitate a science talk with their students, prompting them to think about patterns they observed. During the entry event, teachers present the driving essential question, "How does light interact with other things?" which connects all learning experiences to the learning targets. They will begin learning about sources of light.

This will lead to the introduction of the design challenge which is to create a tool that can send a distress signal using light and various materials. Students will begin to ***ask*** questions like: How do different objects affect light? What can I use to affect light? How far does the light source have to travel to be effectively used as a warning?

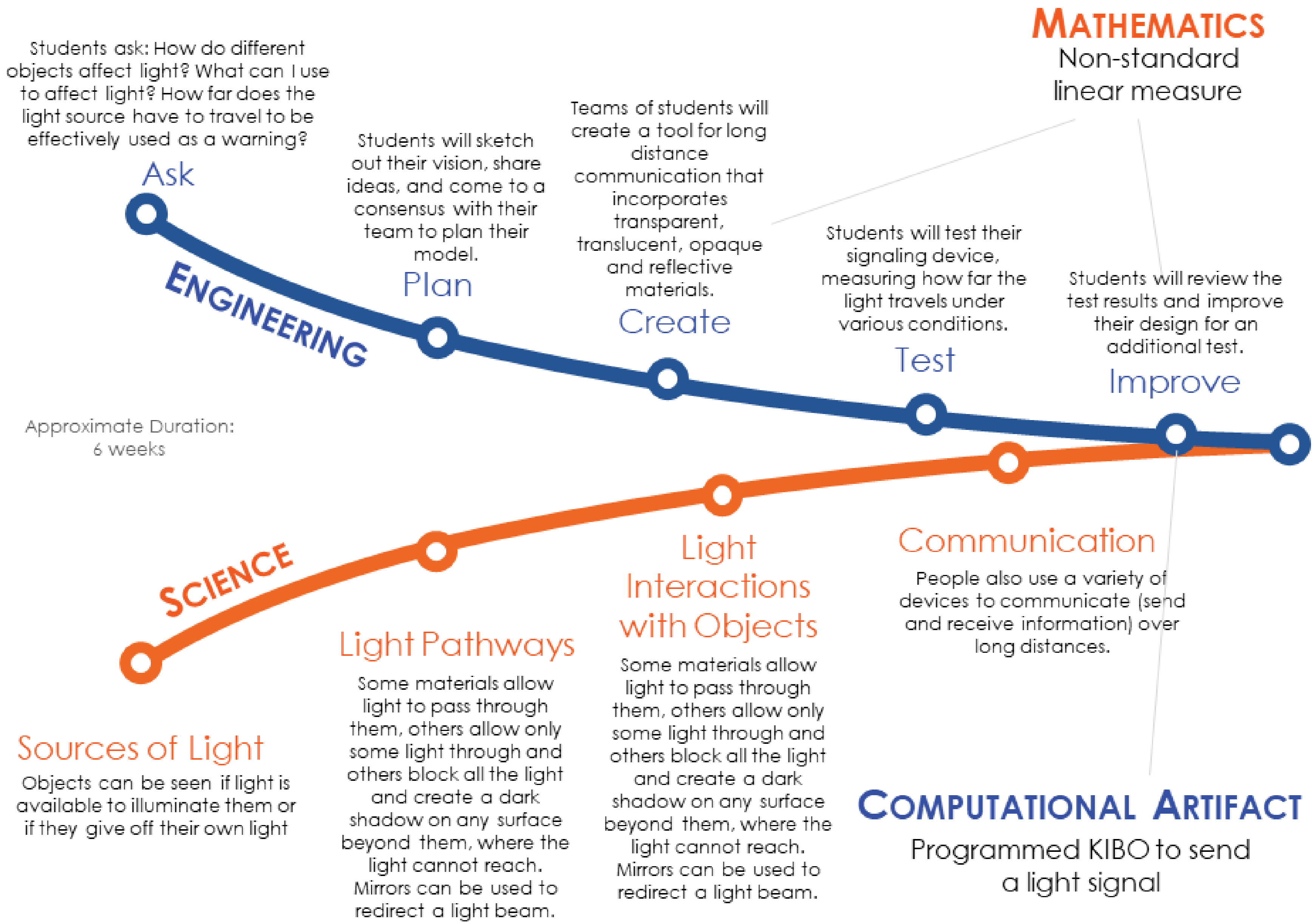
Sequence 2: Students will learn more about light pathways and factors that influence whether light passes through objects. Students will imagine they are a signal maker who needs to create a light that will send a warning across a distance. Students will sketch out their vision, share ideas, and come to a consensus with their team to ***plan*** their model.

Sequence 3: Students will continue to learn about light and how it interacts with objects. Students will consider the materials available and being to ***create*** their device using KIBO. Teams of students will create a tool for long distance communication that incorporates transparent, translucent, opaque and reflective materials. Students will continue to learn about light and how it interacts with objects.

Sequence 4: Students will learn more about communication using light and will ***test*** the effectiveness of their design, measuring how far their signal light is able to travel. Students will record their observations on each trial.

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

Integrated Unit Storyline



Integrated Unit Wayfinder

Inventory the experiences of students

Present the anchoring phenomenon

Students collaborate with each other

Students read, hear, and view source material

Students and teachers reflect on the work and processes of students to assess learning progress

Launch design challenge; elicit and record questions students **ask** about the challenge

Facilitate 5E science lesson sequence for sources of light

Give students time to ***plan*** their design solution

Facilitate 5E science lesson sequence for light pathways

Provide time and materials for students to ***create*** their design

Embed measuring length with non-standard units

Introduce expectations for computational artifact

Connect students with a STEM-related professional to inform their design solution

Let students conduct ***tests*** of their design solution and collect data

Support students in developing their computational artifact

Facilitate 5E science lesson sequence for light interaction with objects

Designate time for students to ***improve*** and re-test their design solution

Facilitate 5E science lesson sequence for communication

Students write and speak to share their design solution and learning beyond the classroom

Engineering or Computer Science | Math or Science | Student Connections | Ongoing Actions

STEM Dive

Engineering

Design Challenge: Create a device that sends a light signal

Type of Engineering: Optical Engineering

The Engineering Design Process (EDP) and Engineering Standards

EDP Step	Standard and Grade Band End Points from the *Framework*
Ask *How do different objects affect light? What can I use to affect light? How far does the light source have to travel to be effectively used as a warning?*	**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 will sketch out their vision, share ideas, and come to a consensus with their team to plan their model.*	**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 *Teams of students will create a tool for long distance communication that incorporates transparent, translucent, opaque and reflective materials.*	
Test *Students will test their signaling device, measuring how far the light travels under various conditions.*	**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 will review the test results and improve their design for an additional test.*	

Computer Science (Technology)

Computer Science Integrations

Description of Student Engagement

Students program a KIBO robot to send a signal using light

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)

- Programmed KIBO that sends a light signal

Hardware

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

- Computer
- Kinderlab Robotics KIBO

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

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

- Optional software could be used to run simulations of light and/or signaling devices

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.AP.10** Model Daily Processes by creating and following algorithms to complete tasks.
- **K-2.AP.11** Model the way programs store data.

Science

Focal Standard

1-PS4-4 Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.* [Clarification Statement: Examples of devices could include a light source to send signals, paper cup and string "telephones," and a pattern of drum beats.] [*Assessment Boundary: Assessment does not include technological details for how communication devices work.*]

Related Content Standards

1-PS4-2 Make observations to construct an evidence-based account that objects can be seen only when illuminated. [Clarification Statement: Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light.]

1-PS4-3 Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light. [Clarification Statement: Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror).] [*Assessment Boundary: Assessment does not include the speed of light.*]

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

Anchoring Phenomenon

Teachers engage students with an anchoring phenomenon by having pairs of students play shadow tag.

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
Sources of Light	• Objects can be seen if light is available to illuminate them or if they give off their own light (1-PS4-2)	7

Key Concept	Key Learnings	# of Days
Light Pathways	• Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam. (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.) (1-PS4-3)	7
Light Interactions with Objects	• Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam. (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.) (1-PS4-3)	7
Communication	• People also use a variety of devices to communicate (send and receive information) over long distances. (1-PS4-4)	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 will measure the distance light travels from their warning device. Students can also measure the distance the KIBO travels.

Standards for Mathematical Content

1.MD.2 Express the length of an object as a whole number of length units, by laying multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps. Limit to contexts where the object being measured is spanned by a whole number of length units with no gaps or overlaps.

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 Ideas and Details

RI.1.1 Ask and answer questions about key details in a text.

Writing Standard: Text Types and Purposes

W.1.1 Write opinion pieces in which they introduce the topic or name the book they are writing about, state an opinion, supply a reason for the opinion, and provide some sense of closure.

W.1.3 Write narratives in which they recount two or more appropriately sequenced events, include some details regarding what happened, use temporal words to signal event order and provide some sense of closure.

Speaking and Listening Standard: Comprehension and Collaboration

SL.1.1 Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.

SL.1.2 Ask and answer questions about key details in a text read aloud or information presented orally or through other media.

Speaking and Listening Standard: Presentation of Knowledge and Ideas

SL.1.4 Describe, people, places, things, and events with relevant details, expressing ideas and feelings clearly.

SL.1.5 Add drawings or other visual displays to descriptions when appropriate to clarify ideas, thoughts, and feelings.

Language: Vocabulary Acquisition and Use

L.1.4 Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on Grade 1 Reading and Content, choosing flexibly from an array of strategies.

- **L.1.4.a** Use sentence-level context as a clue to the meaning of a word or phrase.
- **L.1.4.b** Use frequently occurring affixes as a clue to the meaning of a word.
- **L.1.4.c** Identify frequently occurring root words (e.g., look) and their inflectional forms (e.g., looks, looked, looking).

Unit Vocabulary

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

- **beam**: A beam is a line of light coming from a source (such as the sun or a headlight). (Source: https://www.merriam-webster.com/dictionary/beam)
- **brightness**: Brightness is a measure of how much light is being emitted by an object.
- **flash**: A flash is a sudden bright light (like a flash if lightning). (Source: https://www.merriam-webster.com/dictionary/flash)
- **illuminate**: To illuminate means to shine a light on (something). (Source: https://www.merriam-webster.com/dictionary/illuminate)
- **light**: Light is the bright form of energy given off by something (as the sun) that makes it possible to see. (Source: https://www.merriam-webster.com/dictionary/light)
- **opaque**: Opaque means not letting light through or not transparent. (Source: https://www.merriam-webster.com/dictionary/opaque)
- **point of reference**: Point of reference can refer to your point of view: What direction are you looking? It can also mean something that you use as a basis for comparison. For example, is Light A brighter than Light B? You are using one of the lights and making a judgment about the other light being brighter or dimmer.
- **reflect**: To reflect means to bend or throw back (waves of light, sound, or heat). (Source: https://www.merriam-webster.com/dictionary/reflect)
- **shadow**: A shadow is the dark figure cast on a surface by a body that is between the surface and the light. (Source: https://www.merriam-webster.com/dictionary/shadow)
- **translucent**: Translucent means not completely clear or transparent but clear enough to allow light to pass through. (Source: https://www.merriam-webster.com/dictionary/translucent)
- **transparent**: Transparent means clear enough or thin enough to be seen through. (Source: https://www.merriam-webster.com/dictionary/transparent)

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. Name some places you have seen light before.

2. Think about when it is really dark around you.
   a. When it is really dark ***inside***, what are some things you can still see?
   b. When it is really dark ***outside***, what are some things you can still see?

3. Have you seen a shadow before? If so, what do you remember about it? *(Additional Prompts: What did it look like? Where did it appear? Did it move?)*

4. Tell about a time you used a mirror. *(Additional Prompts: What did you do? What did you notice?)*

5. When you want to tell somebody something, what things (devices) do you use to tell them?

Aligned Learnings

1. Responses to this item provide insight into students' experiences with sources of light. 1-PS4-2

2. Responses to this item provide insight into students' experiences with objects that illuminate or are illuminated. 1-PS4-2

3. Responses to this item provide insight into students' experiences with shadows. 1-PS4-3

4. Responses to this item provide insight into students' experiences with mirrors. 1-PS4-3

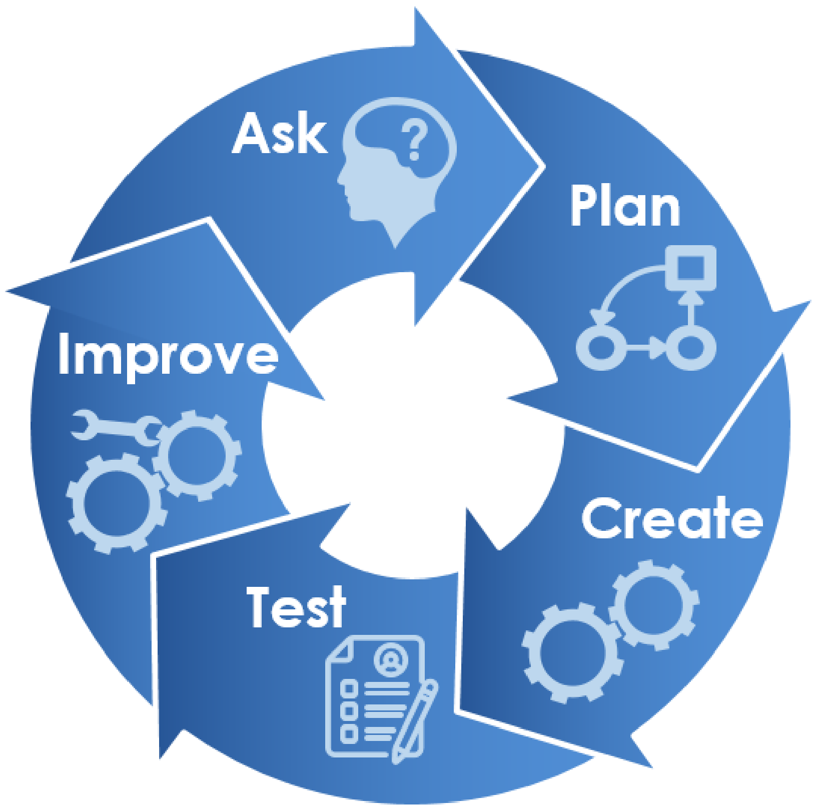
5. Responses to this item provides insight into students' experiences with communication methods. 1-PS4-4

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 an optical 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. (K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3)	
	Computer Science Students program the KIBO to send a light signal (K-2.DA.7, K-2.AP.10, K-2.AP.11)	
	Collaboration Students contribute and support others with honesty and kindness (SL.1.1)	
	Communication Students speak and write about their ideas clearly using accurate vocabulary (W.1.1, W.1.3). Students will share thoughts, read, and listen to learn from others. (SL.1.1)	
	Science Students observe and collect evidence to explain how light travels from sources and interacts with other objects as well as explain how it can be used to communicate messages. (1-PS4-4)	

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:

- **Optometrist or Ophthalmologist** (Health Science and Medical Technology)
- **Electrician** (Building and Construction Trades)
- **Stage Manager for a Theater or Television studio** (Arts, Media, and Entertainment)

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:

- **Optometrist or Ophthalmologist** (Health Science and Medical Technology)
  - How do you use light to help you see the health of a patient's eyes?
  - What are the potential negative impacts of too much light on your eyes?
  - Does everyone see light in the same way, or are there differences?
  - How do lenses in glasses help improve someone's vision?
  - Do we see differently in high light as compared to relative darkness? Why?
- **Electrician** (Building and Construction Trades)
  - When you are wiring a home or a building what do you consider when setting up a lighting structure?
  - Do you select different types of lighting depending on the kinds of tasks that will be done in the area? (For example, an office area or a kitchen)
  - Are there particular spaces (for example, an x-ray room) where the illumination (brightness of the light) is intended to be at a lower level?
  - If you were lighting a school or an office, how might your selections for lighting differ?
- **Stage Manager for a Theater or Television studio** (Arts, Media, and Entertainment)
  - How bright are the lights that you use on the stage?
  - Are the lights all white lights like we have in our lamps but only brighter, or are they something else?
  - How can lighting impact how someone appears on stage or television?
  - What do you do to eliminate shadows on people's faces or reflection off of their glasses?

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):

- ☐ 1 set of 6 color paddles
- ☐ 1 laser pointer for teacher (or more if safety protocols can be assured)

Consumable Equipment (classroom totals):

- ☐ 8 powerful flashlights (USB rechargeable or order necessary batteries)
- ☐ 32 mirror sheets (6 X 6)
- ☐ 90 color cellophane sheets (8 X 8)
- ☐ 150 (3 oz.) paper cups
- ☐ 90 paper plates
- ☐ 32 square feet of waxed paper
- ☐ 32 square feet of clear plastic wrap
- ☐ 32 rolls of clear tape

Consumable Equipment (from home or site as available):

- ☐ paper towels
- ☐ cardboard cup holders
- ☐ cardboard egg cartons
- ☐ colored pencils, crayons, markers

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 (student totals):

- ☐ 1 powerful flashlights (USB rechargeable or order necessary batteries)
- ☐ 1 mirror sheets
- ☐ 3 color cellophane sheets
- ☐ 5 (3 oz.) paper cups
- ☐ 3 paper plates
- ☐ 1 square foot of waxed paper
- ☐ 1 square foot of clear plastic wrap
- ☐ 1 roll of clear tape