Special thanks to
Tucson Electric Power
for powering this resource with their support.

Resource developed by
Danielle VanDerlaske and
DaNel Hogan

DaNel.Hogan@waterscenterst.org
STEMAZing Systems Thinking

Primary Predicament

(All resources and teacher slide decks at: https://stemazing.org/primary-predicament/)

Grades: Arizona - 3rd Grade (NGSS – 4th Grade)

Arizona Science Standards (NGSS Correlations)

3.P2U1.1 (NGSS-Partial Correlation: 4-PS4-2) Ask questions and investigate the relationship between light, objects, and the human eye.

Materials/Resources for All Three Parts

Copies for each student:

- Journal 1 – Paint Predicament
- Journal 2 – Let There Be Light
- Journal 3 – Two Sets of Primary Colors
- Decomposed Color Image printout
- Rainbow Ish RYB and CYM
- Ish Drawings Handout

NOTE: All files for the copies needed above can be found at the website listed at the top of this page.

Tools for each student:

- Colored markers, crayons, or pencils

For class:

- Post-its
- Chart paper for recording whole class
- Paintbrushes (enough for students to share in groups)
- Red, Yellow, Blue, Cyan, and Magenta Paints
- Paint trays/paper plates (enough for students to share in groups)
- Bulk bag of M&M's or multi-colored pony beads
- Three Remote Control LED Flood Lights (one-time expense of about $50) Like these or similar (make sure the glass on the lights is not frosted): https://amzn.to/3K5FB9G

Estimated Time: In each part, there are lessons which may be a little shorter or a little longer than the estimated length. Some sessions can also be split into two for shorter sessions.

- Part 1: Paint Predicament – 6 sessions of approximately 30 minutes each
- Part 2: Let There Be Light – 3 sessions of approximately 30 minutes each
- Part 3: Two Sets of Primary Colors – 5 or 6 sessions of approximately 30 minutes

#SciencingAndEngineering Teacher Talk with 3rd grade teacher Danielle VanDerlaske and Robot General Sherrie Dennis: Coming soon!

#STEMAZingPictureBook
Ish by Peter H. Reynolds (one copy for the teacher to read aloud)

Resource developed by
Danielle VanDerlaske and
DaNel Hogan

DaNel.Hogan@waterscenterst.org
STEMAZing Systems Thinking

Advanced Teacher Preparation

1. Note: The primary colors are not red, yellow, and blue, as most of us have been taught in the past. This is a common misconception and throughout these science lessons, students will develop a strong understanding of the real primary colors: cyan, magenta, and yellow. Read the teacher background at the bottom before starting to teach these lessons.
2. Print and staple the copies of Journals 1, 2, and 3. Print double-sided, flipped on the SHORT edge.
3. Journal 1: Paint Predicament has two pages which will need to be cut and folded. You can have students do this on their own when you hand out the journal, or you can prepare them ahead of time. You can put a piece of tape or staple the outside edge where folded. The transparency printouts will be held here.
4. Print out the decomposed color image on transparency film in color and then cut out each colored picture. It is important for these to be cut as accurately as possible for students to be successful when layering them. It is helpful to use a paperclip to keep these four images together for each student.
5. For Part 2: Let There Be Light, you will need a space with no light. You will need to cover any windows in the room with black paper to block any light from entering the room.
6. All the slide decks have teacher notes at the bottom to help lead you through the lessons. Use this in conjunction with the lesson plan for each part.
7. This unit has been developed using the 5E Instructional Model. You can learn more about this model here: https://bit.ly/5Emodelofinstruction. This Primary Predicament unit goes through two complete 5E lessons.

Part 1: Paint Predicament

Materials for Part 1

For each student:

- Journal 1: Paint Predicament (printed double-sided, flipped on the SHORT edge, folded and stapled)
- Decomposed Color Image (printed in COLOR on transparency film)
- Rainbow-ish RYB and CYM (printed on white cardstock)
- Ish Drawings Handout

Class:

- Post-its
- Red, Yellow, Blue, Cyan (Turquoise), Magenta Paints
- Paintbrushes
- Paint trays/paper plates
- Chart paper

Resource developed by
Danielle VanDerlaske and DaNel Hogan

DaNel.Hogan@waterscenterst.org
STEMAZing Systems Thinking

Formative Assessment Probe:

Have students complete the “Paint Predicament” probe found on page 1 of “Paint Predicament” Journal 1. Have students place a post-it on their vote on a chart on the wall for which answer they select and leave posted for later discussion or to document changes in thinking over time.

Primary Predicament - Part 1 Outline:

Lesson component and time	Teacher Actions	Student Actions
ENGAGE (phenomenon included) - 25 minutes	PRIOR TO LESSON - Teacher must have photos (*Wildcats Photo*) printed on transparency film and already cut out and paperclipped together for each student. DURING LESSON - Give students the four colored transparency photos cut apart. Record any ‘testable wonders’ on a chart to revisit the next day. NOTE: Guide students to the wonder about the order in which the colored photos should stack if no students naturally test or question if the order matters.	Students stack images to recompose the photo and record what they notice and wonder on Journal 1 pages 3-4.
EXPLORE- 25 minutes	Present the chart of testable wonders created during Engage. Ask questions using the crosscutting concepts as students test, observe, record.	Students select 2-3 testable wonders from chart and explore using the transparency photos from Engage. Students record extra observations and any data on extra paper. Students share (in partners/ tables/class discussion) their discoveries to the testable wonders they explored.

Resource developed by
Danielle VanDerlaske and DaNel Hogan

DaNel.Hogan@waterscenterst.org
STEMAZing Systems Thinking

EXPLAIN- 25 minutes	Introduce the names of the colors on the transparencies as ***cyan***, ***magenta***, and ***yellow***. Challenge students to combine two colors to make the colors red, blue, and green. (See teacher slides.) Lead class discussion about what they notice about creating these colors. NOTE: students should start realizing they can make the colors red and blue from other colors.	Students use transparency photos to layer in different ways to discover combos and record how to make red, blue, and green Journal 1 page 6.
ELABORATE 30-45 minutes	Read the picture book *Ish* by Peter H. Reynolds to the class and talk about what it means to create an -ish picture. *OPTIONAL BUT RECOMMENDED:* After teacher read-aloud of *Ish,* students make some of their own "Ish" drawings using the Ish Drawings Handout to demonstrate how everyone's drawings are unique and different. NOTE: If you choose the drawing option, this will add some extra time not included in the time frame here in the left column. Assign half the class to paint rainbows by mixing red, yellow, and blue paints. Assign the other half to paint rainbows by mixing cyan, magenta, and yellow paints. NOTE: You may need to give some time to practice mixing paints and show a model rainbow visual on the board so students know the (ROYGBIV) order. ROYGBIV = red, orange, yellow, green, blue, indigo, and violet NOTE: Students will be returning to this during Part 2 of this module to have a better understanding of which "rainbow-ish" is scientifically 'better.'	Students draw their own "ish" drawings and discuss (partners/tables/class) what makes their pictures unique. Students mix paints to create all colors of the rainbow (half using red/yellow/blue to start with and half using cyan/magenta/yellow to start with). Students partner with someone who painted with the opposite set of colored starting paint and discuss what they notice and wonder about the two rainbows. Students record their notices and wonders on Journal 1 page 7.

Resource developed by
Danielle VanDerlaske and DaNel Hogan

DaNel.Hogan@waterscenterst.org
STEMAZing Systems Thinking

EVALUATE (Part 1) - 25 minutes	Display, on the board, the Zometools toys grouped on a cookie sheet by color but decomposed into cyan, magenta, and yellow (slide 25). After student discussions, show the composed image of the Zometools toys on the board and have students discuss how they knew which colors were which.	Students use what they have learned, the notes in their journal, and even the transparencies from previous lessons, to figure out what color each group of Zometool toys will be. Students discuss in groups and then have groups share out what their thoughts were.
EVALUATE (Part 2) - 10-15 minutes	Revisit the formative assessment probe “Paint Predicament” to have students record what they think now. NOTE: The hope is students will start to have a shift in their thinking but if not that is ok. After students place Post-its on the graph, see if there is a shift. Spend some time talking about what students are thinking and trends for the class.	Students reread the probe on student Journal 1 page 1 and record current thinking on page 2. Students record who they now agree with from the probe and place post-its (consider a different color) on the class graph created in the original Formative Assessment Probe.

Resource developed by
Danielle VanDerlaske and DaNel Hogan

DaNel.Hogan@waterscenterst.org
STEMAZing Systems Thinking

Part 2: Let There Be Light

Materials for Part 2

For each student:
- Journal 2: Let There Be Light (printed double-sided, flipped on the SHORT edge, folded and stapled)
- Colored markers, crayons, or pencils

Class:
- Bulk bag of M&M's or multi-colored pony beads
- Three Remote Control LED Flood Lights (Like these or similar: http://bit.ly/20WLEDFloodLights)
- Chart Paper
- Post-its

Formative Assessment Probe:

Have students complete the "Apple in the Dark" probe found on page 2 of "Let There Be Light" Journal 2. Have students place a post-it on their vote on a chart on the wall for which answer they select and leave posted for later discussion or to document changes in thinking over time.

Primary Predicament - Part 2 Outline:

Lesson Component and Time	Teacher Actions	Student Actions
ENGAGE:30-45 minutes (This could also be split into 2 sessions, either between red and blue light sorting or between light sorting and sensemaking.)	*You need to be in a completely dark room for this part of the unit. Cover any windows with dark paper so no light shines through. Pass out paper plates and a handful of either M&Ms or multi-colored pony beads. Students will cover their plate with their journal, then turn out the lights and shine red light from all three of the LED lights. Walk around while students sort the M&M's or pony beads into groups which appear to be the same color.	Students will sort the M&M's or pony beads in the red light.

Resource developed by
Danielle VanDerlaske and DaNel Hogan
DaNel.Hogan@waterscenterst.org
STEMAZing Systems Thinking

	After they have sorted the objects, turn the white room lights back on and let students draw the groups they have with colored markers, crayons, or pencils on page 3 in their journal. Have them record what they notice and wonder on pages 3 and 4. Have students draw a prediction for what colors they will be able to distinguish and which will look the same when sorting the objects using only blue light on Journal 2 page 5. Have students sort either M&Ms or multi-colored pony beads into groups that look the same in a very dark room with only blue light from your LED flood lights turned on. After they have sorted the objects, turn the white room lights back on and let students draw the groups they have with colored markers, crayons, or pencils in the actual half of their observations box on page 5. Have the student record what they notice and wonder on page 5 and 6. After sorting in red light and blue light, you can let students answer the questions on page 7. Have students work together to come up with answers to the prompts and compare responses, especially to the final question. It is not necessary to correct any thinking at this point. This will be revisited later.	Students will record their noticings and wonderings in Journal 2 pages 3-4. Students will make a prediction on Journal 2 page 5 and then sort the M&Ms or pony beads in blue light. Students will record their observations on Journal 2 page 5. Students will record their noticings and wonderings in Journal 2 pages 5-6. Students will work together to complete the sentence starters and answer the question on page 7.

Resource developed by
Danielle VanDerlaske and DaNel Hogan

DaNel.Hogan@waterscenterst.org
STEMAZing Systems Thinking

Part 3: Two Sets of Primary Colors

Materials for Part 3

For each student:

- Journal 3: Two Sets of Primary Colors (printed double-sided, flipped on the SHORT edge, folded and stapled)

Class:

- Chart paper
- Post-its
- PhET Color Vision Simulation (http://bit.ly/PHETcolorvision)

Primary Predicament - Part 3 Outline:

Lesson Component and Time	Teacher Actions	Student Actions
EXPLORE: 25 minutes	Assign the link in the slide for the PhET simulation in google classroom if students are each using a device. Once students log in simply let students play with the simulation while recording noticings and wonderings on Journal 3 page 1. This can also be done as a classroom demonstration but is much better either with every student having their own device or two to three students to a device. The PhET simulations are technology agnostic and will work on everything from cell phones to computers to iPads and so on. You can have a whole group discussion after everyone has had a chance to notice and wonder. You may have students starting to notice things about what the person in the simulation sees when adding or subtracting light. You may need to explain that the flashlights are showing the colors and the bubble shows what the brain sees. Add any new wonders to the class chart paper.	Students will use the phET simulation and record their noticings and wonders on Journal 3 page 1.

Resource developed by
Danielle VanDerlaske and DaNel Hogan

DaNel.Hogan@waterscenterst.org
STEMAZing Systems Thinking

EXPLAIN: 25- 35 minutes	You will introduce the primary colors of light are red, blue, and green. These are the colors of the flashlights on the simulation. Direct students to fill the primary colors of light at the top of Journal 3 page 2 – red, blue, and green. Then have the students complete the middle section of Journal 3 page 2 using the PhET simulation. They are going to turn on the flashlights shown in the journal and record what color they see. After they have all finished, you can demonstrate on your computer and check their answers. Red and green = yellow, red and blue = magenta, green and blue = cyan. The secondary colors of light are colors you get when combining any two primary colors of light. These are essentially the colors just recorded in the middle section. Direct students to record these again on the bottom of Journal 3 page 2 - yellow, magenta, and cyan. After doing this you can use your LED light to do a colored light show with students in a dark room to show that it is not just on a simulation but in real life that your eyes see the same colors both primary and secondary when using real colored LED flood lights in different combinations of red, green, and blue. (See this video for ideas about how to engage students with the LED flood lights: https://bit.ly/PrimaryColorLightShow)	Students will use the phET simulation again and follow the directions on page 2 in Journal 3. Students will record the secondary colors of light on Journal 3 page 2.
ELABORATE: 40 minutes (or you can split this up into two 20 minute sessions with the breakpoint after page 3)	You will ask students to think back to the colored photo activity and what the primary colors of the paint were, not including black. The primary colors of paint are cyan, yellow, and magenta. Students will record these primary colors of paint at the top of page 3. Then you will have students think back to the secondary colors of paint, the colors they made when they combined two primary colors of paint. They may need to use their transparencies and/or Journal 1 to reference. The secondary colors of paint are red, green, and blue. Red is created by combining magenta and yellow. Green is created by combining yellow and cyan. Blue is created by combining cyan and magenta.	Students will look back at their transparencies from part 1 and complete Journal 3 page 3.

Resource developed by
Danielle VanDerlaske and DaNel Hogan

DaNel.Hogan@waterscenterst.org
STEMAZing Systems Thinking

	Next, have students look back to page 2 with the primary and secondary colors of light and then compare them to page 3, the primary and secondary colors of paint. Have them fill in the bottom of page 3 about what they notice when comparing them. Students should notice that the primary colors of light are the secondary colors of paint and the primary colors of paint of the secondary colors of light. You will then explain that the primary colors of paint look the way they do because of the light they reflect to your eye. This may take some extra explanation or modeling with the PhET simulation again. Once you feel students are ready, have them work on page 4 in their journal. Students should record the two colors of light and label the colors in the drawing below the sentence frame as well as the color of the paint splat for good measure. Even better if they can color the paint splat and light arrows in with the correct colors. Cyan and turquoise are essentially the same color when it comes to markers, crayons, and colored pencils. It may be a good time to have students look at their rainbows again and talk about what the differences are and why that may be.	Students should complete and color in Journal 3 page 4. Students can have a discussion about their Rainbow-ishes.
EVALUATE: Part 1-15-20 minutes	Students will look at the image on Journal 3 page 5 of the bananas. You can have them color it in if they want. They need to use what they have learned (they can use the past journal pages) to explain why the banana looks yellow. They can then label the colors being reflected on the picture or color them in. Through discussion, if necessary, have students determine the banana looks yellow because it is reflecting red and green light. Then students can go to page 6 with the images of the apple in a room with lights on and the apple in a room with lights off. Have them color in the apple and the color of light it is reflecting for the top part. The bottom part may require some group discussion about what the apple in a dark room will look like. The rhyming phrase is no light, no sight.	Students will color the bananas and the light it reflects on Journal 3 page 5 and then explain their thinking about this on page 6.

Resource developed by
Danielle VanDerlaske and DaNel Hogan

DaNel.Hogan@waterscenterst.org
STEMAZing Systems Thinking

	For the first part: Your eye sees a red apple because red light reflects off the apple and into your eye. Your eye detects the red light and sends a message to your brain telling it the apple is red. For the second part: In a completely dark room, with no sources of light, your eye would see nothing because there is no light to reflect off the apple and travel to your eye. You can let students completely black out that area or at least put an X over it. (NOTE: A very common misconception is that your eye will somehow adjust given enough time. This likely comes from the fact that we are rarely in a completely dark space with absolutely no light.)	
EVALUATE: Part 2-10 minutes	Revisit the Probe from the beginning of part 2. Students can look back at what they thought at the beginning and then respond again on page 7. If you had a chart with what they thought at the beginning and want students to rechart what they think now you can do that. Let students respond to the probe on page 7. You can allow discussion after they have responded individually. The answer to the probe is A. It truly does not matter how long you are in the room, if there is not light, there is no sight.	Students will look back and revisit their original answer to the “Apple in a Dark Room” probe. They will then decide if they have changed their thinking and explain why.

Special thanks to
TEP
Tucson Electric Power
for powering this resource with their support.
Resource developed by
Danielle VanDerlaske and DaNel Hogan

DaNel.Hogan@waterscenterst.org
STEMAZing Systems Thinking

Teacher Background:

Your **eyes** are amazing organs which allow you to see. Your eyes see objects when light hits an object and reflects off the object into your eye. The retina in your eye detects the light entering your eye and sends a message to your brain about what it is detecting. Your brain then interprets that information and you "see" the object. If there is no light, then you will see absolutely nothing. (**No light, no sight.**) Usually, we have white light illuminating a room or the sun's white light illuminating the outdoors.

Your eye sees color based on the colors of light entering your eye that have reflected off of the object you are looking at. If you only have red light illuminating a room full of objects, the colors you can detect are limited because only red light is available to be reflected. Many objects that are different colors will appear the same color because they are reflecting the same amount of red light for your eye to detect. So, the color of the light illuminating an object definitely impacts the color an object appears to be. This is sometimes noticeable when matching the color of clothes in a room illuminated using fluorescent lights. Fluorescent lights look white but in actuality they have more purple and green light than sunlight. Because of this, clothes might look like they match while you are inside using the fluorescent lights and then they look a little different when outside in the sunlight.

If you ask a physicist what the primary colors are, she will ask you if you are talking about light or paint. It turns out, despite what you may have learned in school yourself, that there are two sets of primary colors and neither one of them is red, yellow, and blue. The **primary colors of light**, used to create colors on the screens of computers, televisions, and smartphones, are **red, green, and blue**. If you were to magnify a white section of a screen that is lit up, you would actually see tiny little light emitting diodes (LEDs) that are red, green and blue. They are sometimes abbreviated **RGB**. You may have noticed these when selecting colored fonts on a computer or colors in a program for drawing on a computer or phone. Using different intensities of these three colors, we can create the full range of colors your eyes can detect. **Secondary colors** are colors created by using two of the primary colors. The **secondary colors of light** are cyan (made by mixing green and blue lights), yellow (made by mixing red and green lights), and magenta (made by mixing red and blue lights).

The **primary colors of paint** are **cyan, yellow, and magenta**. You might recognize these as the colors of ink you buy to put into a color printer or copier (along with black ink). They are sometimes abbreviated **CYMK** (K the abbreviation for black). Mixing cyan, yellow, magenta, and black paint/ink in different quantities allows us to create the most different colors starting with just three colored paints (and black). The **secondary colors of paint**/ink are red (made by mixing magenta and yellow paints), green (made by mixing cyan and yellow paints), and blue (made by mixing magenta and cyan paints). So, the secondary colors of paint are the primary colors of light - red, green, and blue. And, the secondary colors of light are the primary colors of paint - cyan, yellow, and magenta.

PIMA COUNTY
SCHOOL SUPERINTENDENT