Photo by soyunterrorista (Flickr CC)

Have you ever thought about mixing light to make color? How would you go about doing this? Is mixing light similar to mixing paint?

COLOR SHADOWS

The primary colors of light are red, green and blue. Experiment with combinations of these three colors to create every color you can think of in the form of shadows. Take it a step further by creating a light shadow painting or light shadow theater performance, based on the color theories of light.

AGES 10-100

TIME: 10-15 MIN

OBJECTIVES

Students will:

1 PONDER

2-5 minutes

Begin the exercise by asking students some of the following questions to encourage them to begin thinking about light and colors. Add other questions or adjust these based on the knowledge and interest of your students.

- What are the primary colors when mixing pigment? (red, blue, yellow)
- What are the primary colors when mixing light? (red, green, blue)
- Why do pigment and light have different primary colors?
- How could you make other colors of light?
- How many colors can be created independently when mixing light? How many colors can be created simultaneously?
- What careers need to know how to mix colors?
- How do you manipulate shadows and the color of light on a daily basis?

2 EXPLORE

10-15 minutes

COLOR COMBINATIONS

1. Direct the students' attention to the screen and explain that today they will be exploring the colors of light and its shadows.
2. Ask students what they expect to see on the screen when all three lights are turned on and why.
3. Ask one of the students to turn on the power strip (which will turn on the light bulbs) to show them that the combination of the three lights creates white light.
4. Ask, "What color should we make next?"
5. Have students hypothesize what color of bulbs they will need to use to make that color.
6. Invite one or two students to test their hypothesis. They can block specific colors by placing black card stock or black tissue paper in front of that light bulb (not touching the bulb). If the first student's hypothesis turns out to be incorrect, invite another student to come forward and test their hypothesis until you have successfully created

PREPARATION

MATERIALS

- 3 incandescent light bulbs: 1 red, 1 green, and 1 blue
- 3 bulb sockets with 2 prong plug
- 1 power strip
- 1 extension cord
- A large white surface, (whiteboard, white wall, projection screen or a white bed-sheet.)
- Objects to cover light bulbs:2 sheets of black card stock and 3 sheets of translucent black paper (black tissue paper works well)
- Digital camera (optional)
- Tripod for camera (optional)

PREPARATION

- Prepare an area that can be dark or at least dimmed. If necessary, cover any windows with black paper or fabric.
- Set up a projection surface with an open area in front of it where students can experiment.
- Plug the three sockets into a power strip (evenly spaced). Screw the three light bulbs into the sockets. Connect the power strip to an extension cord and place it in front of the projection surface.

the right color.
7. Repeat steps 4-6 with several colors.

Image courtesy of Wikimedia Commons. Author: en:User:Bb3cxv

SHADOW THEATER

Invite one student to hold the power strip with light bulbs and one or two students to control which bulbs are blocked. Encourage the rest of the group to create a shadow theater by creating a variety of colored shadows using their bodies or classroom objects. As they do, ask them questions to help them think about some of the concepts below (or others that you can think of).

- Have the students observe how their shadows interact.
- How does the distance of the lights and objects from the screen impact the colors created?
- What affects the intensity of the colors?
- Challenge the students to see how many different colors they can get display the screen at the same time.
- Challenge the students to get each color to cover the screen, one at a time.

3 EXPAND

Variable time

Take this exercise a step further by experimenting with video or photographic exposures in order to document your light and shadow art. Have students use a digital camera and long exposure times to experiment with creating a light shadow painting. How many color combinations can they represent in their scene? Encourage students to play with movement and exposure time. Encourage students to create a video script based on the color of light and the primary colors of RGB. Could you use this colored shadow technology for the lighting in your next theatrical performance?

MORE FROM THE LEONARDO

- Look for more light-related lesson plans on www.theleonardo.org/learning/resources, including activities using prisms and glow sticks.
- Visit The Leonardo and explore our Digital Corner and Materials Science station to learn how the concepts in this lesson are used in other applications.

WHAT'S GOING ON?

ADDITIVE VS. SUBTRACTIVE COLOR

Additive color refers to color emitted by a light source. Additive color systems start without light (black). Light sources of various wavelengths combine to make a color. The primary colors are red, blue and green.

A subtractive color model explains the mixing of paints, dyes, inks, and other pigments. Each color is caused by absorbing (subtracting) some wavelengths of light and reflecting the others. We see the reflected color(s). The primary colors in a subtractive color model are red, yellow, and green.

ADDITIVE COLOR COMBINATIONS

At least 7 hues of light can be created using combinations of red, blue and green light. These hues include blue, red, green, white, cyan, magenta and yellow. Other hues can be created by changing the proportions of colored light combined.

Red + Green = Yellow
Blue + Green = Cyan
Red + Blue = Magenta

WHAT'S GOING ON?

The human eye perceives the mixture of red light, green light and blue light as white light. When we look at a rainbow, we are seeing this process in reverse - rain water splits white light from the sun into a spectrum of different colors. When one of the colored lights in this exercise is blocked, the ones that are left combine to make a new color. The proportion of each color will affect how the color is expressed. This can be seen as students stand at different distances from the screen to alter the shadow colors.

OUR EYES

The light receptors in the retinas of our eyes that perceive color are called cones. The three main types of cones perceive short, middle, and long wavelengths of light. The short wavelength cones perceive blue-ish light, the middle wavelength green-ish light, and the long wavelength red-ish light. A mixture of these receptors are used to see the full range of colors in the light spectrum. With these three types of cones we can see more than a million different shades of color.

RGB IN TECHNOLOGY

Red, green and blue light combinations are detected or produced by many devices we use on a daily basis. Just a few examples include: TVs, video cameras, digital cameras, image scanners, plasma TVs, computer screens, cell phone displays, and video projectors. Because of differences in technology, R,G,B levels vary not only from manufacturer to manufacturer but also within the same device over time.

ASSESSMENT

UTAH CORE CURRICULUM

5th Grade
- Visual Arts 1.1; 1.3a,b,c,d; 4.3b,d

6th Grade
- Science 6.2a,e
- Visual Arts 1.1; 1.3a,b,c,d; 4.3b,d
- Theater 2.1b

8th Grade
- Science 4.1e

7th-12th Grade
- Foundations of Art I 1.1a,b,c; 4.2b
- Foundations of Art II 1.1a,b,c; 2.2a,b; 4.2b Theater II 3.1b
- Theater III 1.1a,b,c; 3.1; 3.2
- Theater IV 1.1a,b,c; 3.1; 3.2
- Film 1.1; 1.2; 3.3
- Art History and Criticism 1.1a,b,c
- Photography 1.1c; 4.2b

PROCESS AND HIGHER-LEVEL THINKING SKILLS

- Observe
- Hypothesize
- Investigate
- Discover patterns
- Communicate and collaborate
- Play/tinker
- Connect diverse concepts

THE ELECTROMAGNETIC SPECTRUM