BEAM Away the Shadows

Grace Xie | Fall23

Field of Interest: Physics

Brief Overview:
In this lesson, mentees will be exploring various qualities of lights and shadows. Mentees will be able to mix light to explore how the primary colors of light can be used to create the secondary colors of light and white light. They will also learn more on reflection and absorption of light through making red/blue pencil art and even get to design their own puppet show!

Agenda:

- Introduction (5 min)
- Module 1: Watt's Up (5-10 min)
- Module 2: Hidden in Plain Light (15-20 min)
- Module 3: Throw Some Shade (15-20 min)
- Conclusion (5 min)

Main Teaching Goals/Key Terms:	**Mentor Development Goals:**
➔ Primary colors of light ➔ Secondary colors of light ➔ White light ➔ Primary & secondary colors of pigments ➔ Reflection ➔ Black ➔ Shadows ➔ Absorption	➔ Time Management ➔ Adapt ➔ Classroom Management ➔ Connecting to the Real World

Mentor Development Notes

Written by Marine Lyden and Bradley Louie Saito

Break it Down

Concepts such as absorption can be difficult to explain to mentees, especially as it is harder to visualize than the other concepts in this lesson. Try to break down this idea into simpler examples that mentees are more likely to have seen before, such as a sieve that lets through liquid while preserving solids.

Classroom Management

The mentees get very excited to engage with many of the module activity materials. This means that activities could get out of hand if module activity tasks are not distributed among mentors. Make sure each mentor monitors their small groups' handling with all materials, such as colored pencils and popsicle sticks. Make sure that mentees also share these items respectfully with one another.

Adapt and Overcome!

Take the mentors' grade levels into account when running the site. Mentees of different ages will have different interests between the modules. For example, if you have younger site members or a site that loves building, consider spending more time on the puppet show.

Connect to the Real World

The topics in this lesson, such as visible light and shadows, are in the mentees' everyday lives. Encourage mentees to share examples of how lights and shadows affect everyday life. Ask questions to pique their curiosity, such as what they think the world would be like without a shadow or light. The mentees will most likely ask you questions in return, so be prepared to engage with their curiosity and learning!

Background for Mentors

Module 1

- Primary colors of light
- Secondary colors of light
- White light
- Primary & secondary colors of pigments

Visible light is a type of electromagnetic wave around the wavelength of 380-700 nm. All colors of visible light can be broken down into the **primary colors of light** which include: red, blue and green. Combining the primary colors of light can generate the **secondary colors of light**, which include: yellow, cyan and magenta. **White light** is a combination of all colors of light. This can be demonstrated by shining white light through a prism.

The mixing of **pigment** follows different rules than the mixing of light. The primary colors of pigment are: yellow, cyan and magenta, while the secondary colors of pigment are: red, blue and green, which can be mixed together to create black.

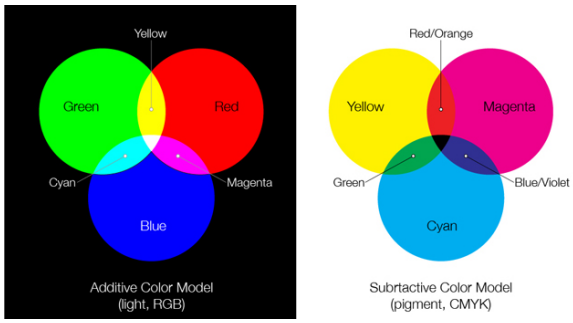

Figure 1: Mixing light VS mixing pigment

A **shadow** is created when an object blocks the path of light. However, an object's shadow doesn't always have to be black. If multiple colored lights are shined on an object, it can cast various colored shadows depending on which color of light it is blocking.

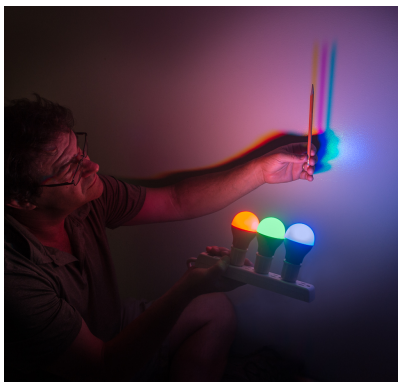

Figure 2: Colored shadows

Module 2

- Reflection
- Black

Light can be reflected, refracted, transmitted or absorbed. **Reflection** is the change of direction of light when it strikes a surface. When white light strikes a colored surface, the surface will reflect the color of light that it is and absorb all other colors of light. For example, the reason we see blueberries as blue is because they only reflect blue light, which is then detected by the eye.

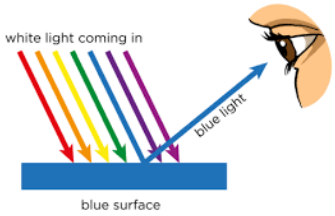

Figure 1: Colored object reflect light the color they are

When all light shined on an object is absorbed and no light is reflected, an object appears as **black**. For example, under blue light, a red object that only reflects red light will absorb the blue light shining on to it and appear as black.

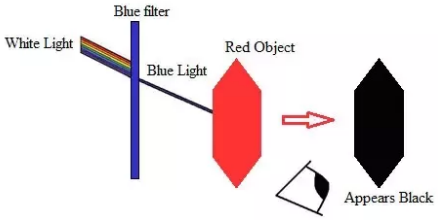

Figure 2: Under blue light, objects not blue will appear as black

Using the rules of reflection and absorption, we can create drawings in different colors that will only be revealed when a certain color of light is shined on it.

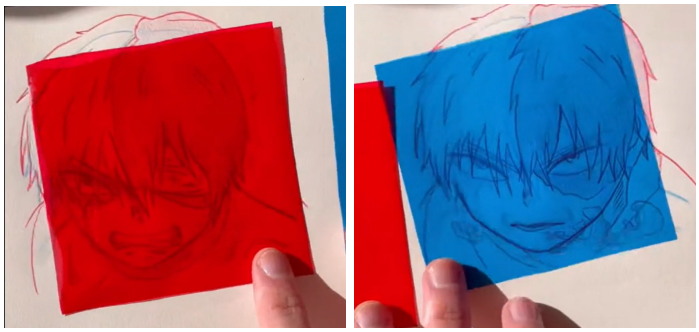

Figure 3: Red and blue drawings under cellophane

Module 3

- Shadows
- Absorption

As mentioned previously, **shadows** are dark areas created when an opaque object blocks a light source. A shadow is essentially a 2D projection of a 3D object!

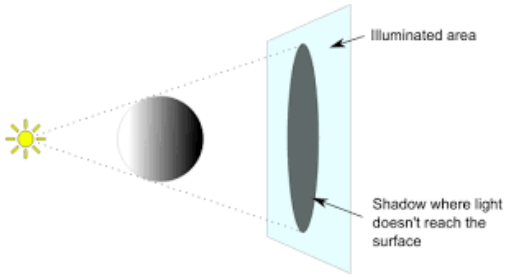

Figure 1: How shadows are formed

The **shape of the shadow** is affected by the shape of the object and the orientation of the source of light in respect to the object.

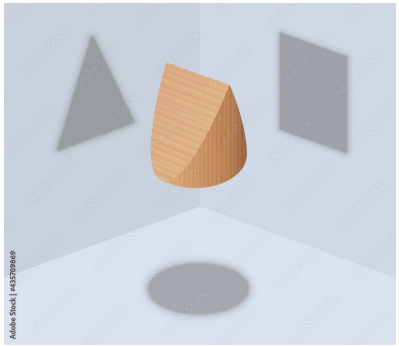

Figure 2: Shadows of the same object can be different

The **size of the shadow** can be manipulated by moving the object closer to or further away from the light source. When the screen on which a shadow is projected on is the same, the closer an object is to a light source, the larger the shadow and the further an object is away from a light source, the smaller the shadow.

Figure 3: Shadows of the same object can be different, part 2

Introduction

Concepts to Introduce ● Light ○ What types of light can be seen in day-to-day light? Sunlight? Man-made LED lights...? ● Shadows ○ That dark thing behind you when you stand under the sun!	**Questions to Pique Interest** ● Have you noticed that your shadow looks different during different times of the day? Do they look longer during noon or in the morning? ● Did you know that a lunar eclipse is caused by the shadow of the earth blocking the moon?
Scientists, Current and Past Events ● The sundial is an ancient way to tell time based on the position of the sun. During different times of the day, the dial would cast a different shadow!	**Careers and Applications** ● Lights and shadows are both Physics related topics! Recommend learning more about physical sciences to the mentees if they find this lesson particularly interesting!

Module 1: Watt's Up

Mentees will be mixing the primary colors of light to create the secondary colors of light and white light with flashlights!

Teaching Goals	**Materials**
1. **Primary colors of light:** red, green and blue 2. **Secondary colors of light:** Mixed from the primary colors of light. They include: cyan, magenta and yellow 3. **White light:** a mix of all colors of light 4. **Primary & secondary colors of pigments:** different from the primary colors of lights	• Flashlights (3 per group) • Colored cellophane paper (3 per group) • Tape • White paper sheet • Acrylic paint

Different Methods For Teaching

1. **Primary colors of light:** Compare these to the primary colors of pigments that mentees are more familiar with! You cannot make them from mixing other colors!
2. **Secondary colors of light:** Different from the primary colors, you can get these colors through mixing!
3. **White light:** Some examples of white light in everyday life are sunlight and LED lights!

Procedure

1. Mentors will demonstrate how mixing of primary colors can generate new secondary colors via the mixing of acrylic paints.
2. Mentors will then demonstrate the mixing of light using flashlights.
3. Cover flashlights with different colors of cellophane paper and secure them with tape.
4. Shine flashlights onto white paper and see how different colors of lights mix into new colors of light.
5. Ask mentees to compare how the mixing of lights differs from the mixing of colors.
6. Try putting an object to block the light, observe what color of shadow it casts into the other lights.

Figure 1: *Mixing blue and yellow paint to make green paint*

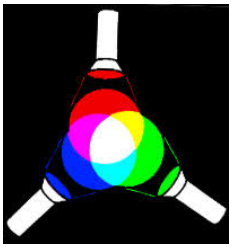

Figure 2: *Mixing of colored lights to create white light*

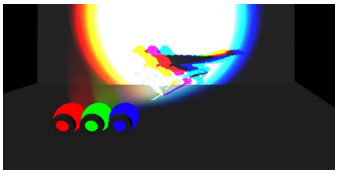

Figure 3: *Object casts different color shadows in*

different lighting conditions

Classroom Notes

Make sure mentees are not shining flashlights into each others' eyes. The activity may be easier to run if lights in the classroom are turned off. Flashlights should be held close to table for best effect.

Module 2: Hidden in Plain Light

Mentees will be drawing two drawings in different colored pencils on top of each other and using colored lights to selectively hide one of the drawings.

Teaching Goals

1. **Reflection:** objects appear the color they are because they reflect that color of light
2. **Black:** a color the objects take on when all light is absorbed and no light is reflected.

MD Goals

- **Time Management**

When you give mentees a free-form activity such as drawing, keep in mind that time can become an issue. Give mentees plenty of advance notice as to when you need to move onto the next module.

Materials

- Red & blue cellophane
- Red & blue colored pencils (1 set per mentee)
- Paper (1 per mentee)

Different Methods For Teaching

1. **Reflection:** Mentees can try imaging a mirror. Why can mentees see themselves? It's because the mirror is "reflecting" the light back into their eyes.
2. **Black:** Think about why the hot stone massage stones are black colored? It's because they absorb heat better than white colored ones!

Procedure

1. Mentees will be given red pencils, blue pencils and a piece of paper.
2. They will create drawings with each colored pencil on top of it. (see Figure 1.)
3. Mentors will shine a red light/hold red cellophane on top of their drawing to hide the red pencil markings and show the blue drawing (see Figure 2.)
4. Mentors will shine a blue light/hold blue cellophane on top of their drawing to hide the blue pencil markings and show the red drawing (see Figure 3.)
5. Mentees will be encouraged to think about why the pencil drawings appear as "black" on paper rather than the color they were drawn with originally.
6. Mentors should encourage mentees to make

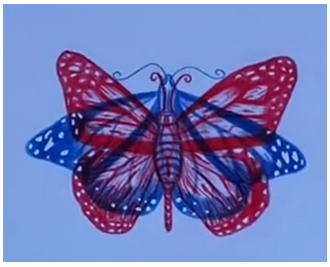

Figure 1: *Picture drew in both blue and red pencil under white light*

Figure 2: *Blue pencil showing under red light*

drawings that cover each other slightly!

Figure 3: *Red pencil showing under blue light*

Classroom Notes

Make sure mentees are not shining flashlights into each others' eyes. The activity may be easier to run if lights in the classroom are turned off. Pressing down lightly while drawing will yield better results. Time management! (You can also double fold the cellophane for better results)

Module 3: Throw Some Shade

Mentees will be creating a puppet show with cardboard cut-outs on popsicle sticks!

Teaching Goals

1. **Shadows:** when a light's path is blocked by an object, it creates a black blob where there is no light
2. **Absorption:** the tendency of objects to soak up lights

- **Connecting to the Real World**

Shadows are in our everyday lives, so encourage mentees to introduce and connect real-world examples of shadows in their everyday lives. Pique the mentees' curiosity and suggest why they think most objects cast shadows while some (like glass) don't!

- **Adapt**

If you are running short on time, turn this module into a demo! If you have plenty of time left, you can extend this activity into a more intricate activity (e.g a puppet show!).

Materials

- Flashlights
- White Butcher Paper
- Cardboard (1 board per site)
- Construction Paper/ Printer Paper
- Coffee Stirrers/ Popsicle Sticks
- Scissors
- Tape

Different Methods For Teaching

1. **Shadows:** Does your shadow look like you? Think about why that might be!
2. **Absorption:** Why does the sunlight not shine through you, but rather create a shadow behind you? It's because your body is absorbing the light and not letting it pass right through you!

Procedure

1. Use two chairs and tape to set up white butcher paper sheet and shine a flashlight underneath it to create a small "puppet theater."
2. Mentors will demonstrate hand shadows to mentees.
3. Mentors will assign a small skit that the mentee will try to create as a classroom on the whiteboard (ex: a monster trying to take down a city.)
4. Hand out materials to mentees.
5. Mentees will be creating puppet prompts to help them act out the skit.
6. Prompt mentees to hold their puppets further away from the light source. How does the

Figure 1: *"I saw it work in the video I watched so I probably don't need to lesson test"*

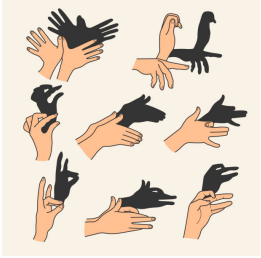

Figure 2: *Hand shadows that mentors will*

shadow it casts change?

7. The skit will be performed at the end of the lesson as a group.

demonstrate

Figure 2: *Puppet show showcase*

Classroom Notes

This activity should be done in the dark. It might be helpful to assign different parts of the story to different groups of mentees to act out. Mentors are encouraged to help with the cardboard cutting.

Conclusion

Mentors should talk about how lights and shadows can be seen all around us. Tell mentees that they should try exploring and having fun with shadows even outside the classroom.

References

- Play with Color & Light, American Museum of Natural History. https://www.amnh.org/explore/ology/physics/play-with-color-and-light
- Instructions for: Red View/Blue View https://www.pa.uky.edu/sciworks/physicspettingzoo/Red%20View%20Blue%20View.htm

Summary Materials Table

Material	**Amount per Site**	**Expected $$**	**Vendor (or online link)**
Flashlights	1 per group	$12.79	Amazon
Colored cellophane paper	3 per group	$6.99	Amazon
Rubber bands	3 per group		
Red & blue pencils			
Cardboard	1 sheet per group		
White butcher paper sheet	1 per classroom		
Popsicle sticks			
Tape			
Scissors			