5E STEM: An Investigation of Light from Visible to Invisible

5-7 days, 45-60 minute classes

Authors

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SUBJECT/GRADE LEVEL

Subject Area: Science, Earth & Space

Grade Level: 5-8

MATERIALS

- Google Slides (see Resources section)
- Two identical flashlights (with fresh batteries)
- Measuring tape or meter sticks
- Darkened space (classroom, hallway, or gym)
- Chart paper or whiteboard
- Student notebooks or graphic organizers for note-taking
- Copies of the provided texts (in Resources)
- Prism, glass of water, or old CD (for rainbow demonstration)
- Colored cellophane filters (red, blue, green)
- Graph paper or access to digital graphing tools
- Access to computers/tablets for research (optional)
- Writing paper or digital document for opinion piece drafts
- Rubric for argumentative writing and scientific explanation (see attached)
- M&M's (various colors)
- Darkened room
- Colored lights (red, green, and blue)
    - Colored cellophane or gels over regular flashlights can be used, or LED fixtures with RGB emitters, according to ETC Lighting.
- White sheet of paper or a white paper plate
- Optional: Markers to label sections on the paper or plate

STANDARDS

Next Generation Science Standards

- **5-ESS1-1:** Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.
    - Compare the sun to other stars and discuss how distance plays a factor
- **5-PS1-3:** Make observations and measurements to identify materials based on their properties.
    - Celestial bodies are composed of different compounds, which give off different types of light, as observed by use of filters
- **MS-PS4-2:** Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
- **MS-ESS1-3**: Analyze and interpret data to determine scale properties of objects in the solar system.

Mathematics Standards | Common Core State Standards

- **6.RP.A.1**: Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
- **7.RP.A.2:** Recognize and represent proportional relationships between quantities.

English Language Arts Standards | Common Core State

- **W.5.1:** Write opinion pieces on topics or texts, supporting a point of view with reasons and information.
    - Introduce a topic or text clearly, state an opinion, and create an organizational structure in which ideas are logically grouped to support the writer's purpose.
    - Provide logically ordered reasons that are supported by facts and details.
    - Link opinion and reasons using words, phrases, and clauses (e.g., consequently, specifically).
    - Provide a concluding statement or section related to the opinion presented.
- **SL.5.4:** Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
- **RST.6-8.1**: Cite specific textual evidence to support analysis of science and technical texts.
- **RST.6-8.7**: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

LESSON OBJECTIVES

Students will be able to:

1. **Brightness of Celestial Bodies**

- Explain why the sun appears brighter than other stars due to its closeness to Earth.

2. **Properties of Light**
   - Explain that white light consists of the visible spectrum (rainbow colors).
   - Describe how filters affect the colors we see, and the types of light that might be invisible to our own eyes but how filters help us to see them
   - Understand visible light as part of the broader electromagnetic spectrum emitted by the sun.
3. **Scientific Inquiry and Argumentation**
   - Engage in scientific inquiry by asking questions, collecting evidence, and constructing arguments.
   - Support scientific arguments with evidence from observations and texts.
   - Construct well-organized argumentative writing with clear claims, reasons, and evidence.

CAREER CONNECTION(S)



Mentor Background: LTC William Koch: "LTC Will Koch is an Academy Professor and the Program Director for Space Science in the Department of Physics and Nuclear Engineering. He graduated from the United States Military Academy in 2004 with a Bachelor of Science Degree in Physics. He was commissioned in the Aviation Branch and served as a Platoon Leader in the 3rd Squadron, 17th Air Cavalry Regiment during the surge in Baghdad, Iraq. He later served as company commander in the 1st Squadron, 6th Air Cavalry Regiment during Operations Iraqi Freedom and New Dawn. Following his commands, LTC Koch earned his master's degree in Physics from Massachusetts Institute Technology (MIT) in 2013. He taught in the Department of PaNE from 2013-2016. After his junior faculty time, he spent two years working in NASA's Astronaut Office focusing on the SpaceX Commercial Crew Program. He was the prime stakeholder for many of the crew-vehicle interface requirements on the SpaceX Crew Dragon spacecraft. LTC Koch then earned his PhD in Nuclear Science & Engineering from MIT before returning to USMA as an Academy Professor.
LTC Koch is married to the former Miss Vanessa Kurtiak of Flint, Michigan. They have two incredible children and one poorly behaved cat."

STEM Careers:

Astronomer: Studies stars, planets, galaxies, and the universe.
Astrophysicist: Focuses on the physics of celestial objects and phenomena.
Meteorologist: Studies weather patterns and forecasts the weather.

Climatologist: Studies Earth's climate, including long-term weather patterns and climate change.
Geologist: Studies Earth's physical structure and substances, including rocks, minerals, and soil.
Hydrologist: Studies water on Earth, including its movement, distribution, and quality.
Educator/Teacher: Teaches science and other subjects to students of all ages.
Science Communicator: Explains scientific concepts to the public through writing, videos, or presentations.
Cartographer/GIS Specialist: Creates maps and analyzes spatial data, which can include mapping celestial objects, weather patterns, or environmental features.
Photographer/Videographer: Captures images and videos of natural phenomena like the stars or other deep space objects.
Writer/Journalist: Researches and writes articles, books, or reports on scientific discoveries, environmental issues, or cultural topics.

ENGAGEMENT

Brief Description: Engage: 1-2 days, or 45 minutes total
Objective: Spark student curiosity about the apparent brightness of celestial objects and the phenomena of light and shadows, prompting initial questions.

Procedures:

Phenomenon Introduction: Celestial Brightness (15 minutes): This activity introduces the core phenomenon of apparent brightness. Students are prompted to observe and question why the Sun appears so much larger and brighter than other stars. This sets the stage for understanding the role of distance in apparent brightness (NGSS 5-ESS1-1). It also taps into prior knowledge and sparks curiosity.

- **Teacher Actions:**
  - Begin by asking open-ended questions to activate prior knowledge and observations about the night and day sky (e.g., "When you look at the night sky, what do you see? Do all the stars look the same? How does the sun look during the day compared to stars at night?").
  - Display high-quality images and short, engaging videos of the night sky (showing various stars, some brighter than others, etc). Ensure videos are short and focused to maintain engagement.
  - Facilitate a whole-class discussion, encouraging all students to share their initial thoughts and observations.
  - Record student "Notices" (what they see) and "Wonders" (their questions) on a chart paper or whiteboard. This models scientific observation and questioning.
  - Guide the discussion towards the central question: "Why does the sun appear so much brighter than other stars, and how does this relate to other bright objects we see in the sky?"

- **Student Actions:**
  - Actively observe images and videos of celestial objects.
  - Share their existing knowledge and observations about the Sun and stars.
  - Contribute to the "Notice & Wonder" chart by articulating what they observe and what questions they have.
  - Engage in respectful discussion with classmates.
- **Formative Assessment:**
  - **Observation of Discussion:** Listen for student misconceptions (e.g., thinking the sun is the biggest star because it looks biggest) or accurate initial ideas.
  - **"Notice & Wonder" Chart Analysis:** Review student questions to gauge their initial understanding and areas of curiosity. Are their questions relevant to apparent brightness or light?
  - **Exit Ticket (Optional):** Ask students to write down one thing they "noticed" and one thing they "wondered" about the celestial objects.
- **Adaptations:**
  - **Individual Learners:**
    - **Support:** Provide sentence stems for "Notice & Wonder" (e.g., "I noticed ____. I wonder ____."). Pre-teach key vocabulary like "apparent" and "actual" if needed, though formal introduction comes later. Use visual aids with clear labels for students with language barriers.
    - **Challenge:** Encourage students to formulate more complex or multi-part questions for the "Wonder" section. Ask them to predict what might make some stars appear brighter than others.
  - **Virtual Options:**
    - Share high-resolution images and videos via screen share or a shared document.
    - Use a collaborative digital whiteboard (e.g., Jamboard, Google Slides) for the "Notice & Wonder" chart, allowing all students to contribute simultaneously.
    - Utilize breakout rooms for small group discussions before returning to the main group.
    - Use polling features (e.g., Mentimeter, Zoom polls) for quick checks of initial ideas.

Phenomenon Activity: Light & Sky Observations (10-15 minutes): This activity introduces students to various light phenomena (rainbows and filtered light) that are ultimately connected to the sun's energy and properties of light. It lays the groundwork for understanding the visible spectrum, the electromagnetic spectrum, and how light interacts with matter (NGSS 5-PS1-3).

- **Teacher Actions:**

        - Show compelling images and short, high-quality videos of a vibrant rainbow, and sunlight passing through a colored filter.
        - For each visual, pose guiding questions that prompt observation and initial hypotheses about the source and nature of the colors/lights (e.g., "Where do these colors come from? Why do they appear in this order? What causes these amazing lights? Why are they different colors? How does this filter change the light? What does this tell us about light and color?").
        - Facilitate a brief discussion after each visual, connecting them to the sun as the energy source.
        - Encourage students to add new "Wonders" to the class chart based on these observations.
    - **Student Actions:**
        - Observe the images and videos attentively.
        - Respond to guiding questions, sharing their initial thoughts on the origin of the colors and lights.
        - Contribute new questions to the "Notice & Wonder" chart about light and color.
    - **Formative Assessment:**
        - **Oral Responses:** Listen for student understanding of light as a source of color and the sun as the ultimate energy source.
        - **"Wonder" Contributions:** Check if student questions are moving towards concepts of light properties or interactions.
    - **Adaptations:**
        - **Individual Learners:**
            - **Support:** Provide a word bank of descriptive terms for colors and light (e.g., "bright," "dim," "red," "blue," "green," "sparkling," "glowing"). Offer sentence frames for answering questions.
            - **Challenge:** Ask students to predict which colors they might see if filters were applied
        - **Virtual Options:**
            - Ensure high-quality video and image sharing.
            - Use the chat feature for quick responses to guiding questions.
            - Consider sharing links to interactive simulations of light and color if available and age-appropriate.

Phenomenon Activity: Hidden Image (Day 1: 15 minute): Images that use color can represent more than just what we see — colors can show data, patterns, or hidden information. Scientists often use color maps to display things like temperature, elevation, or chemical composition. Today, we'll explore how colors help us understand complex information in images.

- **Teacher Actions:**

        - Show several color map images (e.g., heat maps, topographic maps, or astronomical images).
        - Ask students to observe and describe what they see, focusing on colors and patterns.
        - Guide students with questions like:
            - What do you notice about the colors?
            - What might the colors represent?
            - How do the colors help you understand the image?
        - After discussing a few images, introduce the color-by-number nebula activity, explaining that nebula images often use colors to show different gases or temperatures.
        - Distribute the color-by-number sheets and color keys.
        - Circulate to support and encourage thoughtful coloring and observation.
    - **Student Actions:**
        - Observe each image carefully and share observations about colors and patterns.
        - Discuss ideas about what the colors might represent in each image.
        - Listen to the teacher's explanation about color maps and their purpose.
        - Complete the color-by-number nebula activity by matching colors to numbers.
        - Reflect on how using color helps show information that might be hard to see otherwise.
    - **Formative Assessment:**
        - **Exit Ticket:** Have students write or share one insight about how color helps reveal information in an image.
        - **Think-Pair-Share:** During the image discussion, ask students to explain their reasoning about color meaning to a partner, then share with the class.
        - **Color-by-Number Review:** Check completed sheets for accuracy and understanding of color representation.
    - **Adaptations:**
        - **Individual Learners:**
            - Provide printed or digital color keys with clear, large visuals for students needing extra support.
            - Offer pre-highlighted sections or partial color guides for students who struggle with fine motor skills or color recognition.
        - **Challenge:**
            - Ask students to create their own color maps or legends based on data you provide.
            - Encourage research on why certain colors are chosen for scientific images (e.g., infrared, ultraviolet).

- Have students compare different types of color maps and explain pros and cons of each.
- Introduce concepts like false-color imaging and have students analyze examples.

- **Virtual Options:**
  - Share images and color-by-number sheets digitally via screen share or learning platform.
  - Use interactive tools where students can color digitally or drag/drop colors.
  - Facilitate breakout room discussions for the observation/sharing part.
  - Use chat or voice responses for formative assessment activities.
  - Record your explanations so students can review at their own pace.

EXPLORATION

Brief Description: Explore: 1-2 Days, or 45-60 minutes total

Objective: Students conduct hands-on investigations to gather data on apparent brightness due to distance, the splitting of white light, and the effect of filters.

Procedures:

Discovering the spectrum with M&M's and colored lights (Day 2): This hands-on experiment provides a tangible way for students to explore color perception, light absorption, and reflection. It helps build a foundational understanding of how objects get their color by interacting with light, which is crucial for later understanding the visible spectrum and how images of celestial objects are created.

- **Teacher Actions:**
  - Before the activity, ensure the room can be completely darkened. Test colored light sources.
  - Briefly explain the goal: to observe how M&M colors appear under different colored lights and to record these observations.
  - Distribute M&M's and white paper/plates to small groups. If desired, guide students to divide the paper or plate into sections and label them for the different M&M colors (red, orange, yellow, green, blue, brown).
  - Guide students through each step of the procedure, emphasizing careful observation and recording.
  - Circulate among groups, asking probing questions (e.g., "What color does the red M&M look like under green light? Why do you think that is? Which colors are hard to tell apart under this light?").
  - Facilitate a post-activity discussion, connecting observations to the concepts of color perception, light absorption, and reflection.
- **Student Actions:**

        - Follow safety instructions for a darkened room.
        - Spread M&M's on their prepared surface.
        - Attempt to sort the M&M's into their designated color groups based on their appearance under red light, then green light, then blue light, observing and recording the changes in appearance with each color.
        - Note which candies were difficult to sort or appeared to change color.
        - Observe the sorted M&M's in regular light and compare them to the recorded observations.
        - Participate in group and class discussions, sharing their observations and initial explanations.
    - **Formative Assessment:**
        - **Observation of Student Sorting:** Note if students are making accurate observations about color changes and if they are systematically testing each light.
        - **Recorded Observations:** Review student notes/tables to see if they accurately recorded their findings and documented which colors were difficult to distinguish.
        - **Discussion Contributions:** Listen for student explanations that begin to link observed color changes to light absorption/reflection (e.g., "The blue M&M looked black under red light because it absorbed the red light").

    - **Adaptations:**
        - **Individual Learners:**
            - **Support:** Provide a pre-made table for recording observations with clear headings and columns for each light color. Work with a small group of students to guide them through the sorting process. Use larger M&M's or other colored objects if fine motor skills are a challenge. Pre-label the sorting areas on the paper.
            - **Challenge:** Ask students to predict the outcome for an M&M color not explicitly tested (e.g., "What would a yellow M&M look like under blue light?"). Have them design a follow-up experiment to test their hypothesis using different colored candies or objects.
        - **Virtual Options:**
            - This activity is challenging to replicate directly virtually.
            - **Alternative:** Share videos demonstrating the M&M experiment under different colored lights. Use interactive online simulations of light and color filters (e.g., PhET Interactive Simulations) where students can virtually manipulate light and objects to see color changes. Students can record observations from the simulation and explain the scientific principles.

Light Exploration: Rainbows, Visible Spectrum, & Filters (Day 2&3 - 20-25 minutes): This activity explores the properties of white light and how it interacts with different materials. Students will see that white light is composed of multiple colors (the visible spectrum) and how filters selectively transmit certain colors while absorbing others (NGSS 5-PS1-3). This is foundational for understanding how images of celestial objects through the use of filters are created later in the lesson.

- **Teacher Actions:**
  - **Rainbow Activity (Day 2):** In a darkened area of the classroom, demonstrate how a prism, a glass of water (with sunlight shining through it onto a white surface), or an old CD (held under a light source) splits white light into a rainbow. Point out the order of colors (Red, Orange, Yellow, Green, Blue, Indigo, Violet - ROYGBIV).
  - **Filter Activity (Day 3):** *See Explain Section*
  - Facilitate discussions after each activity, explicitly linking observations to the idea that white light is made of colors and that filters absorb/transmit specific colors.
  - Formally introduce the term "visible spectrum" as the portion of the electromagnetic spectrum that is visible to the human eye.
- **Student Actions:**
  - Actively observe the rainbow demonstration, noting the colors and their order.
  - Participate in discussions, sharing what they observed and their initial ideas about why it happened.
- **Formative Assessment:**
  - **Discussion Contributions:** Listen for student explanations that indicate an understanding that white light is composed of colors
  - **Drawing/Labeling:** Ask students to draw a rainbow and label its colors, or draw a simple diagram showing light passing through a filter and changing color.
  - **Virtual Options:**
    - Share high-quality videos demonstrating prism effects and light filters.
    - Utilize online interactive simulations for light and color mixing/filtering (e.g., PhET Interactive Simulations: "Color Vision" or "Light and Color"). Students can manipulate virtual light sources and filters and record their observations.

EXPLANATION

Brief Description: Explain (1-2 Days or 45-60 minutes total)

Objective: Students conduct hands-on investigations to gather data on apparent brightness due to distance, the splitting of white light, and the effect of filters. They also begin observing shadows.

Procedures:

Light Exploration: Rainbows, Visible Spectrum, & Filters (Day 2&3 - 20-25 minutes): This activity explores the properties of white light and how it interacts with different materials. Students will see that white light is composed of multiple colors (the visible spectrum) and how filters selectively transmit certain colors while absorbing others (NGSS 5-PS1-3). This is foundational for understanding how images of celestial objects through the use of filters are created later in the lesson.

- **Teacher Actions:**
  - **Filter Activity (Day 3):** Provide colored cellophane filters (red, blue, green) and flashlights to small groups. Instruct students to shine the flashlight through different filters onto a white surface and observe how the light changes color. Then, have them view different colored objects (e.g., colored construction paper, markers, or even the M&M's from the previous activity) through different filters, noting how the objects' apparent colors change.
  - Facilitate discussions after each activity, explicitly linking observations to the idea that white light is made of colors and that filters absorb/transmit specific colors.
  - Formally introduce the term "visible spectrum" as the portion of the electromagnetic spectrum that is visible to the human eye.
- **Student Actions:**
  - Experiment with the colored filters, shining light through them and observing how both the projected light and the appearance of objects change.
  - Record their observations about how colors change when viewed through different filters.
  - Participate in discussions, sharing what they observed and their initial ideas about why it happened.
- **Formative Assessment:**
  - **Observation of Engagement:** Are students actively experimenting with the filters and making careful observations? Are they able to describe the changes they see?
  - **Discussion Contributions:** Listen for student explanations that indicate an understanding that white light is composed of colors and that filters block some colors while letting others pass through.
- **Adaptations:**
  - **Individual Learners:**
    - **Support:** Provide pre-cut cellophane filters. Guide students' hands if they struggle with manipulating the filters. Use simplified language when explaining "absorption" and "transmission." Provide a checklist of observations to make.
    - **Challenge:** Ask students to combine two different colored filters and predict the resulting color. Have them research other ways light can be split or filtered in nature (e.g., why the sky is blue, the colors of sunsets).

        - **Virtual Options:**
            - Utilize online interactive simulations for light and color mixing/filtering (e.g., PhET Interactive Simulations: "Color Vision" or "Light and Color"). Students can manipulate virtual light sources and filters and record their observations.

Flashlight Investigation: Apparent Brightness (20-30 minutes): This is a direct, hands-on model for understanding apparent brightness due to distance (NGSS 5-ESS1-1). Students will see that an object's actual brightness doesn't change, but its perceived brightness does, depending on how far away the observer is. This directly parallels why the sun appears brighter than distant stars.

- **Teacher Actions:**
    - Before the activity, identify and prepare a suitable darkened space (classroom, hallway, or gym). Mark distances clearly (e.g., with tape or cones at 1 meter, 5 meters, 10 meters, 15 meters, 20 meters).
    - Divide students into small groups (3-4 students per group).
    - Clearly explain the procedure: One student stands at the "starting line" with one flashlight (representing a light source, like the sun). Another student stands at a designated distance (start at 1 meter, then move to 5m, 10m, 15m, 20m) with the second flashlight (representing a celestial object at varying distances). The rest of the group observes and records.
    - Distribute two identical flashlights per group and copies of the simple data table.
    - Emphasize that the flashlights should remain identical (same batteries, same model) to ensure a fair test.
    - Circulate, ensuring groups are measuring distances accurately and making careful observations. Ask guiding questions: "Is the flashlight actually getting dimmer, or just *looking* dimmer? What do you notice about the size of the light as it moves further away?"
    - Facilitate a whole-class discussion to synthesize findings and connect them to celestial objects.
- **Student Actions:**
    - Work cooperatively in assigned roles within their groups.
    - Accurately measure distances using measuring tape or meter sticks.
    - Observe the apparent brightness of the two flashlights at varying distances.
    - Record observations in their data tables, describing the apparent brightness (e.g., "Very bright, almost same," "Noticeably dimmer," "Much dimmer, tiny point of light").
    - Participate in the class discussion, sharing their group's findings and drawing connections between distance and apparent brightness.
- **Formative Assessment:**

        - **Data Table Review:** Check if students accurately recorded observations and noted the diminishing apparent brightness with increasing distance. Look for descriptive language in their observations.
        - **Discussion Contributions:** Listen for student explanations that differentiate between "apparent" and "actual" brightness. Are they making the connection to the sun and stars (e.g., "The sun is like the flashlight close up, and other stars are like the flashlight far away")?
        - **Quick Write:** Ask students to write one sentence explaining what they learned about distance and brightness from the flashlight experiment.
    - **Adaptations:**
        - **Individual Learners:**
            - **Support:** Provide pre-labeled data tables with example descriptive words. Assign roles that match student strengths (e.g., a student who struggles with writing can be the "distant flashlight holder" or "measurer"). Use visual cues for distances (e.g., colored tape on the floor).
            - **Challenge:** Ask students to predict the brightness at an even greater distance, or to design a way to quantify the "dimness" (e.g., using a light meter app on a tablet if available and appropriate). Have them consider how this experiment models light spreading out.
        - **Virtual Options:**
            - This activity is difficult to do hands-on virtually.
            - **Alternative:** Share pre-recorded video demonstrations of the flashlight experiment at different distances, clearly showing the setup and the apparent brightness. Use online interactive simulations that allow students to manipulate distance of a light source and observe light intensity (e.g., a simple light intensity simulator). Students can record data from the simulation and discuss their observations.

ELABORATE

Brief Description: Elaborate (1-2 Days or 60-70 minutes total)

Objective: Students develop scientific explanations for apparent vs. actual brightness, the visible and electromagnetic spectrum, using evidence from their explorations and provided texts and images.

Connecting the Model to Reality with Texts: (45-50 minutes): This section formalizes the scientific concepts of apparent vs. actual brightness, using the flashlight model as an analogy and reinforcing with

factual information from provided texts. It also introduces the visible and electromagnetic spectrum, and how filters work, building on the "Explore" activities. This directly addresses NGSS 5-ESS1-1 and supports 5-PS1-3.

- **Teacher Actions:**
  - Begin by reviewing the flashlight demonstration, explicitly connecting it to the concept of apparent brightness. Ask: "How is our flashlight model like the sun and other objects in space?"
  - Formally introduce and define key terms:
    - **Apparent Brightness:** How bright an object looks from Earth.
    - **Actual Brightness:** How much light an object (like a star) actually gives off.
    - **Distance:** The space between Earth and a celestial object.
  - Introduce Text 1 and Text 2: "Actual Brightness versus Apparent Brightness" and “Space Based Astronomy”. Decide on a reading strategy (e.g., read aloud as a class, paired reading, small group reading with assigned roles).
  - Guide post-reading discussions, focusing on extracting key evidence from the texts that supports the central argument
  - Formally introduce the "visible spectrum" based on the rainbow activity, emphasizing it's the part of light we can see. Briefly introduce the "electromagnetic spectrum" as a larger range of energy, with visible light being just a small part, and emphasize the sun emits all these forms of energy.
  - Explain how colored filters work (absorption/transmission) based on the filter activity, relating back to the hidden image activity and applying it to telescope filters and the electromagnetic spectrum.
- **Student Actions:**
  - Participate in the review of the flashlight demonstration, using scientific vocabulary to explain the concepts.
  - Engage in reading Text 1 & 2, actively looking for evidence.
  - Participate in discussions, identifying key facts and evidence from the text to support the argument.
  - Articulate the scientific argument in their own words, using the new vocabulary.
  - Ask questions about the scientific concepts and the reliability of information.
- **Formative Assessment:**
  - **Discussion Responses:** Listen for student use of new vocabulary (apparent brightness, actual brightness, distance, visible spectrum) and their ability to connect the flashlight model to the sun/stars based on the text evidence and the M&M candy lab with the filters for imaging.

        - **Graphic Organizer/Note Check:** Have students fill out a simple graphic organizer (e.g., a Venn diagram comparing sun and other stars, or a T-chart comparing the Sun and other stars based on actual vs. apparent brightness and distance).
        - **"Think-Pair-Share":** Pose a question like, "Explain to your partner why the sun looks brighter than other stars, even if some stars are much bigger."
    - **Adaptations:**
        - **Individual Learners:**
            - **Support:** Provide sentence frames for summarizing text information. Highlight key sentences or vocabulary in the texts. Use a read-aloud strategy for struggling readers. Offer simplified definitions for complex terms. Provide a glossary of new scientific terms.
            - **Challenge:** Ask students to research the actual brightness of a specific star and compare it to the sun, then explain why it still appears dimmer. Have them explain the difference between reflection and emission of light using examples.
        - **Virtual Options:**
            - Use screen sharing for texts. Utilize annotation tools on shared documents to highlight key information.
            - Employ breakout rooms for small group reading and discussion, followed by a main room share-out.
            - Use online quizzes or interactive flashcards for vocabulary review and concept checks.

Connecting the Model to Reality with Images: (20 minutes): This section will have students apply their knowledge of filters and their understanding about the electromagnetic spectrum and apply it to images of deep space celestial objects that they have seen from organizations such as NASA.

- **Teacher Actions:**
    - Provide students with a composite image of a deep space object (e.g., a galaxy) that combines data from multiple wavelengths or filters.
    - Explain the scientific process of creating composite images, emphasizing how different filters capture various types of light (visible, infrared, X-ray, etc.).
    - Guide students to observe the image carefully, noting colors and features that correspond to different wavelengths.
    - Facilitate discussions or small group work to help students describe how the composite image is formed by merging these filtered images.
    - Encourage students to connect this process to what they have learned about light and telescopes.
    - Provide graphic organizers or charts to help students organize their observations and descriptions.

        - Support students with questions like, “Why do you think scientists use different filters?” and “What can we learn from combining these images?”
        - Summarize key points and clarify misconceptions before moving to assessment.
    - **Student Actions:**
        - Examine the composite image carefully, observing colors, shapes, and patterns.
        - Use notes or graphic organizers to describe how the image was created by combining filtered images.
        - Discuss with peers the role of filters and why multiple wavelengths are important for understanding space objects.
        - Make connections between this process and prior knowledge about light and telescopes.
        - Ask questions to deepen understanding and clarify any confusion.
        - Prepare to explain the process and significance of composite imaging in their own words.
    - **Assessment:** Students will create a written or oral explanation that includes:
        - What a composite image is.
        - The steps scientists take to create composite images using different filters and wavelengths.
        - Why composite images provide more information than a single image. Assessment will be evaluated based on accuracy, clarity, use of scientific vocabulary, and completeness.
    - **Adaptations:**
        - **Individual Learners:**
            - **Support:**
                - Provide simplified explanations or short videos about filters and composite imaging.
                - Offer sentence starters or fill-in-the-blank graphic organizers.
                - Allow verbal responses or one-on-one discussions instead of writing.
                - Pair with a peer buddy for collaborative support.
            - **Challenge:**
                - Invite research on specific types of filters or telescopes used in composite imaging.
                - Have students create a simple digital composite image using free online tools.
                - Ask for a comparison between composite images from different wavelengths and what each reveals.
                - Encourage writing a short report on a recent discovery made possible by composite imaging.

- **Virtual Options:**
  - Share digital composite images and supporting videos through the learning platform.
  - Use virtual breakout rooms or discussion boards for collaborative analysis.
  - Provide editable graphic organizers online for students to complete and submit digitally.
  - Allow students to record and upload oral explanations or presentations.
  - Schedule live Q&A or support sessions to address questions.
  - Use interactive tools or simulations that demonstrate how filters work in telescopes.

EVALUATION

Brief Description: Evaluate (2-3 days, or 120 minutes total)

Objective: Students will write an essay explaining how they encounter and interact with different types of light and filters in their daily lives, including examples such as social media filters, and elaborate on how these filters are beneficial for scientists (ex: creating composite images of deep space celestial objects).

Procedures:

Introducing Argumentative Writing (ELA) (15-20 minutes): This section transitions to the ELA component, focusing on argumentative writing (ELA W.5.1). Students learn that scientific understanding isn't just about knowing facts, but about constructing a supported argument. This prepares them for drafting their opinion piece.

- **Teacher Actions:**
  - Explain the purpose of argumentative writing in science: to support a claim with evidence. Emphasize that scientists don't just state facts; they support arguments with evidence.
  - Introduce the concept of an "opinion piece" or "argumentative essay" in ELA. Discuss its key components: Claim/Opinion (what you believe), Reasons (why you believe it), Evidence/Facts (support from observations or texts), and Conclusion (summary and final thought).
  - Provide a clear, simple example of an opinion piece (initially non-science related) and model how to identify its components together as a class.
  - Discuss the rubric for argumentative writing, highlighting what a strong argument looks like.
- **Student Actions:**
  - Listen actively and take notes on the components of argumentative writing.

        - Participate in identifying the parts of the example opinion piece.
        - Ask clarifying questions about the writing structure and the rubric.
    - **Formative Assessment:**
        - **Quick Check:** Ask students to define "claim" and "evidence" in their own words.
        - **Thumbs Up/Down:** After reviewing the example, ask students to show thumbs up if they can identify the claim, thumbs down if unsure.
        - **"Turn and Talk":** Have students turn to a partner and explain in their own words what an argumentative essay needs.
    - **Adaptations:**
        - **Individual Learners:**
            - **Support:** Provide a graphic organizer with labeled sections for Claim, Reasons, Evidence, and Conclusion. Offer sentence starters for each section (e.g., "My opinion is...", "One reason is...", "The experiment showed...").
            - **Challenge:** Ask students to identify the strongest and weakest parts of the example argument and explain why, or to brainstorm different ways the same argument could be structured.
        - **Virtual Options:**
            - Use shared digital documents for the example opinion piece, allowing students to highlight or annotate the different parts.
            - Utilize polling features for quick checks of understanding the components.
            - Post a short video explaining argumentative writing components for review.

Planning the Argumentative Piece (10-15 minutes): Students apply the argumentative writing structure to their scientific understanding of the sun's apparent brightness. This planning phase ensures they have a clear claim and supporting evidence before drafting.

- **Teacher Actions:**
    - Guide students to identify their main claim for the essay: "The sun appears brighter than other stars because it is much closer to Earth."
    - Help them brainstorm reasons based on their "Explore" activities (flashlight experiment, light properties) and "Explain" texts (factual distances, electromagnetic spectrum).
    - Prompt them to recall specific evidence for each reason (e.g., "What did the flashlight experiment show us? What facts did the text give about distances? How did the prism/filters demonstrate light properties?").
    - Provide a graphic organizer for planning (e.g., a simple outline or a boxes-and-bullets organizer), emphasizing that this is a roadmap for their writing.
    - Review the optional reasons (light properties, distance, etc) and let students choose which they want to include based on their comfort level and depth of understanding.
- **Student Actions:**

        - Use their notes from previous activities and texts to fill in their planning graphic organizer.
        - Formulate their claim and supporting reasons.
        - Identify specific evidence for each reason, ensuring it comes from observations or provided texts.
        - Think about how to structure their essay to logically present their argument.
    - **Formative Assessment:**
        - **Circulate and Confer:** Walk around the room, checking individual planning sheets. Ask students to explain their reasons and evidence orally. Provide immediate feedback and guidance (e.g., "That's a great reason, now tell me, what specific observation from the flashlight experiment proves that point?").
        - **Peer Check:** Have students briefly share their plan with a partner to get initial feedback on clarity and completeness.
    - **Adaptations:**
        - **Individual Learners:**
            - **Support:** Provide a partially filled-in graphic organizer with the main claim and some pre-filled reasons, allowing students to focus on adding evidence. Provide sentence frames for articulating evidence (e.g., "My evidence from the flashlight experiment is...", "According to the text, the sun is...").
            - **Challenge:** Encourage students to include additional reasons or evidence beyond the core requirements, or to think about how to address potential counter-arguments (e.g., "Some people might think the sun is the biggest star, but...").
        - **Virtual Options:**
            - Use a shared digital graphic organizer (e.g., Google Docs, Jrello) where students can type their plans.
            - Utilize breakout rooms for small group planning discussions and peer feedback.
            - Teachers can review digital plans asynchronously or during individual virtual check-ins.

Drafting the Argumentative Piece (45-60 minutes): This is the core writing phase where students synthesize their scientific knowledge and ELA skills to construct a coherent argumentative essay. They apply the structure learned and integrate evidence, developing their voice as scientific communicators.

- **Teacher Actions:**

        - Remind students to use their planning graphic organizers as a guide.
        - Emphasize writing in their own words and using linking words and phrases (e.g., "for example," "this shows that," "therefore," "in conclusion") to connect ideas smoothly.
        - Circulate, providing individualized support and feedback on content, organization, and the effective inclusion of scientific evidence.
        - Encourage students to refer back to the provided texts for factual evidence and to their science notebooks for observation details.
    - **Student Actions:**
        - Write a first draft of their argumentative essay, following their plan.
        - Focus on clearly stating their claim (opinion) in the introduction.
        - Develop body paragraphs that explain their reasons and support them with specific evidence from the flashlight activity, light experiments, and the provided texts.
        - Include a concluding statement that restates their claim and summarizes their main reasons.
        - Use linking words and phrases to create smooth transitions between sentences and paragraphs.
        - Work independently, but may ask the teacher for clarification or assistance.
    - **Formative Assessment:**
        - **"Check-in Point":** After 15-20 minutes, ask students to highlight their main claim and one piece of evidence in their draft for a quick teacher check.
        - **Targeted Feedback:** Provide specific, actionable feedback to students as they write, focusing on one or two areas for improvement (e.g., "Can you add more detail from the flashlight experiment here?" or "Make sure your linking word connects these two ideas more clearly.").
        - **"Stop and Jot":** Have students pause and jot down how they are using evidence from the texts or experiments in their writing.
    - **Adaptations:**
        - **Individual Learners:**
            - **Support:** Provide a sentence bank of scientific vocabulary and linking phrases. Allow students to dictate parts of their essay to a scribe or use speech-to-text tools. Provide a checklist for essay components to help them self-monitor.
            - **Challenge:** Encourage students to use more complex sentence structures or to incorporate a broader range of scientific vocabulary. Have them consider adding a concluding thought that looks to future research questions or implications.
        - Virtual Options:

- Students can draft in a shared digital document (e.g., Google Docs) where the teacher can provide comments and feedback in real-time or asynchronously.
- Utilize virtual "writing conferences" in breakout rooms or individual calls to provide personalized support.

Refine and Edit (20-30 minutes): This phase focuses on improving the quality of the argumentative essays through revision and editing, reinforcing ELA W.5.1. Peer feedback and self-reflection are crucial for refining their scientific arguments and writing skills.

- **Teacher Actions:**
  - Provide clear instructions for peer editing, focusing on specific criteria from the rubric (e.g., "Is the claim clear? Is there enough evidence from experiments and texts? Are linking words used effectively? Is the conclusion strong?").
  - Model how to give constructive, kind, and specific feedback (e.g., "I noticed you have a great claim, but could you add more details from the flashlight experiment in this paragraph?").
  - Facilitate a discussion on common errors or areas for improvement observed in drafts.
  - Guide students through self-revision strategies, encouraging them to reread their work aloud to catch awkward phrasing or missing words.
  - Collect drafts for final teacher feedback before presentation, or provide a final opportunity for students to make revisions based on teacher comments.
- **Student Actions:**
  - Engage in peer editing, providing and receiving constructive feedback on their argumentative essays.
  - Review their own drafts, looking for areas to improve clarity, organization, scientific accuracy, and grammar/spelling.
  - Make revisions to their essays based on feedback from peers and the teacher.
- **Formative Assessment:**
  - **Peer Feedback Quality:** Observe the quality and specificity of feedback students are giving each other.
  - **Revision Evidence:** Review revised drafts to see if students incorporated feedback and made significant improvements to their arguments and writing.
  - **Self-Reflection:** Ask students to write a brief reflection on the most challenging part of the writing process and how they overcame it, or what they learned about revising their work.
- **Adaptations:**
  - **Individual Learners:**

        - **Support:** Provide a checklist for peer editing with very specific questions. Pair students with strong editors who can provide clear, supportive guidance. Offer direct teacher conferencing for intensive revision support.
        - **Challenge:** Ask students to focus on refining their scientific vocabulary or adding more sophisticated linking phrases. Have them consider how their argument could be made even more persuasive for a specific audience.
    - **Virtual Options:**
        - Use features in shared digital documents (e.g., Google Docs "Suggesting" mode) for peer and teacher feedback.
        - Utilize virtual breakout rooms for peer editing sessions, ensuring students know how to use the digital commenting tools.

Presenting Arguments (20-30 minutes, ongoing): This is the summative assessment for argumentative writing. Students practice public speaking (ELA SL.5.4) and demonstrate their comprehensive understanding of the scientific argument and supporting evidence.

- **Teacher Actions:**
    - Establish clear expectations for presentations (speaking clearly and at an understandable pace, making eye contact, using appropriate facts and relevant, descriptive details to support main ideas).
    - Provide a rubric for presentation assessment (can be part of the argumentative writing rubric or separate).
    - Manage time for presentations and Q&A sessions.
    - Facilitate respectful Q&A sessions, encouraging constructive questions from the audience.
- **Student Actions:**
    - Present their argumentative essays to the class, speaking clearly and using evidence from their observations and readings.
    - Answer questions from classmates and the teacher about their argument and evidence.
    - Listen respectfully to their peers' presentations and formulate thoughtful questions.
- **Formative Assessment:**
    - **Peer Feedback:** Have students use a simplified rubric to provide feedback to presenters on clarity, evidence, and delivery.
    - **Teacher Observation:** Use the full rubric to assess individual student presentations.
    - **Q&A Engagement:** Note the quality of questions asked by the audience and the presenters' ability to respond effectively.
- **Adaptations:**
    - **Individual Learners:**

- **Support:** Allow students to present in small groups first to build confidence. Provide note cards with key points or a script to follow. Allow students to use visuals (e.g., their graphs, diagrams) to support their presentation.
- **Challenge:** Encourage students to prepare a more dynamic presentation (e.g., using a digital presentation tool like Google Slides, incorporating a short video clip they created to illustrate a concept).

- **Virtual Options:**
  - Students can present live via video conference, sharing their screen if they have digital visuals.
  - They can pre-record their presentations and share them for classmates to view and provide feedback.
  - Use the chat feature for Q&A during virtual presentations.

RESOURCES

- Engagement Google Slides
- Explore Google Slides
- Explain Google Slides
- Elaborate Google Slides
- Evaluation Google Slides
- Worksheets & Texts Folder

REFERENCES

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