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Overview of Seeing the Moon Educator's Guide

While working through the activities and modules in *Seeing the Moon: Using Light to Investigate the Moon*, students will become more familiar with the electromagnetic spectrum and its uses as a diagnostic tool. Through the enclosed hands-on and inquiry-based activities students collect real data using a spectrometer, examine and compare rock samples, learn about the Earth-Moon system, and map features to uncover the history of the Moon.

Key Content Outcomes

Students will be able to:

- Compare the characteristics of light of different frequencies to white light
- Describe features of a plotted spectrum as wavelength versus brightness
- Demonstrate how spectra can be used to identify and map minerals and rocks
- Describe why the spectra taken by the Moon Mineralogy Mapper / Chandrayaan-1 instrument will obtain more information about the Moon than any observations to date

Key Inquiry Outcomes

Students will be able to:

- Develop descriptions, explanations, predictions, and models using evidence
- Use appropriate tools and techniques to gather, analyze, and interpret data
- Communicate scientific procedures, results, and observations
- Recognize and analyze alternative explanations and predictions
- Express the role of technology in science & exploration

The activities are divided into two primary "modules," with each module containing several steps that include open and guided inquiry investigations, demonstrations, hands-on activities, presentations, and a discussion to synthesize and assess the students' understanding. Also featured is a set of interactive whiteboard activities which showcase many of the images found within the lessons, as well as videos, and other web content.

Multi-Media Support

SMART Notebook Lessons: http://m3.cofc.edu/educators.html

- Access supplemental interactive whiteboard lessons (available in SMART Notebook but available for import in other whiteboard software like Promethian). All student sheets, directions, additional videos, etc. are all at your fingertips!

Moon Mineralogy Mapper Education: http://m3.cofc.edu/educators.html

- A suite of hands-on inquiry based activities engage middle-school students in understanding and interpreting reflectance spectra from Earth and Moon rocks. These activities are part of a suite of educational resources that investigate the geologic history of our Moon, the Chandrayaan-1 Mission, spectrometry, and future lunar exploration.

Moon Posters: http://www.lpi.usra.edu/education/moon_poster.shtml

- A series of three posters explores what C and how Cwe know about our Moon's formation and evolution, and how its history affects lunar resources. The front of the posters provide content depth for students, while back panels provide educators with information, activities, stories about the Moon, resources, and introductions to lunar scientists.

The Electromagnetic Spectrum: http://imagine.gsfc.nasa.gov/docs/science/know_l1/emspectrum.html

- Imagine the Universe investigates the spectrum and offers lesson plans for exploring emission spectra from supernovas for grades 9-12.

Cool Cosmos: http://coolcosmos.ipac.caltech.edu/

- What does a cat look like in the infrared? Tour Yellowstone in the infrared and learn more about this portion of the electromagnetic spectrum through discussion, activities, images, and games at this rich site.

Northwestern University Reflectance Spectroscopy Lab: http://ser.sese.asu.edu/SPECTRA/

- Explore reflectance spectroscopy and perform online analysis of lunar and Martian rocks in this undergraduate laboratory exercise.

Active Astronomy: http://www.sofia.usra.edu/Edu/materials/activeAstronomy/activeAstronomy.html

- Infrared activities (geared for 7th grade through high school)

ALTA II Reflectance Spectrometer: http://www.vernier.com/labequipment/altaspectrometer.html

- The ALTA is a rugged, simple classroom instrument designed to help students in grades 5 to undergraduate learn about light, color, and spectroscopy. Using the spectrometer, students can collect spectral data on the proportions of colored light (including infrared) that reflect from real-world objects. Lesson plans are included.

Rock Around the World: http://ratw.asu.edu/

- Send a rock for spectral analysis! Scientists studying Mars are collecting spectra from Earth rocks so that they can compare the spectral data collected by Martian spacecraft.

Mars Student Imaging Project: http://msip.asu.edu/index.html

- Students in grades 5-12 analyze THEMIS visible spectrum camera aboard NASA's Mars Odyssey spacecraft.

Missions to the Moon

The Moon Mineralogy Mapper (**http://moonmineralogymapper.jpl.nasa.gov/**) is one of NASA's instruments aboard the Indian Space Research Organization's Chandrayaan spacecraft (http://www.chandrayaan-1.com/index.htm). It will map the entire lunar surface, and reveal the minerals of which it is made. Extensive educator content and classroom resources are available on the education pages.

NASA's Lunar Reconnaissance Orbiter mission (**http://lunar.gsfc.nasa.gov/**) will return detailed information about the surface of the Moon and the lunar environment. Explore the Outreach pages for links to more activities and resources.

The Japan Aerospace Exploration Agency's SELENE mission (**http://www.jaxa.jp/projects/sat/selene/index_e.html**) will gather gravity, magnetic, and compositional data from the Moon to help scientists better understand how the Moon formed and has changed through time and to support future exploration.

European Space Agency's SMART-1 spacecraft (**http://www.esa.int/SPECIALS/SMART-1/index.html**) orbited the Moon for three years, collecting spectra to characterize the composition of the lunar surface and provide chemical data that would help scientists understand how our Moon formed.

The Clementine Mission (**http://nssdc.gsfc.nasa.gov/planetary/clementine.html**) was a joint venture between the Department of Defense and NASA to test instruments in long-term space environment and to acquire a global multispectral map of the Moon's surface.

NASA's Lunar Prospector (**http://lunar.arc.nasa.gov/**) spacecraft orbited the Moon, acquiring a global map of lunar resources, gravity, and magnetic fields. The education section offers a teachers guide, lesson plans and a multitude of other resources.

NASA's Galileo Mission (**http://galileo.jpl.nasa.gov/gallery/earthmoon.cfm**) made two passes by the Moon, providing the first multispectral images

This Educator Guide is the result and compilation of hard work by many dedicated lunar scientists and educators. Activities contained herein have been vetted through numerous educator workshops across the country over a five year period. Although primarily designed for grade levels 6-9, many of these activities are also appropriate for upper and lower levels.

Original activities on spectroscopy are combined herein with relevant activities from the NASA's *Active Astronomy Educator's Guide,* and *Exploring the Moon -- A Teacher's Guide with Activities* (NASA EG-1997-10-116-HQ). This educator guide uses traditional U.S. units of measure (e.g., inch, foot, mile). Metric units are provided as comparisons where appropriate. The information provided in this document is accurate as of the original publication date.

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Special thanks to the many teachers who worked with us over the last five years to test and tweak these activities. In particular, the following educators provided critical feedback:

- Barbara Brown, Texas
- Alicia Goodrick, Texas
- Daryl Grantham, Texas
- Ashley Mosher, Texas

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National Science Education Standards (NSES) Concepts Correlated to *Seeing the Moon* Activities		1-1	1-2	1-3	1-4	1-5	2-1	2-2	2-3	3-1	3-2	4-1
K-4th												
Science as Inquiry	Abilities necessary to do scientific inquiry	x	x	x	x	x	x	x	x	x	x	x
	Understandings about scientific inquiry	x	x	x	x	x	x	x	x	x	x	x
Physical Science	Properties of objects and materials	x	x				x	x	x			
	Light, heat, electricity, and magnetism	x	x	x	x	x				x	x	
Earth Science	Properties of earth materials			x						x	x	
	Objects in the sky									x		
Science and Technology	Understandings about science and technology									x		
	Science as a human endeavor									x	x	
5th-8th Grade												
Science as Inquiry	Abilities necessary to do scientific inquiry	x	x	x	x	x	x	x	x	x	x	x
	Understandings about scientific inquiry	x	x	x	x	x	x	x	x	x	x	x
Physical Science	Properties and changes of properties in matter	x	x	x								
Science and Technology	Transfer of energy		x		x	x						
	Science as a human endeavor	x	x	x	x	x	x	x	x	x	x	x
9th- 12th Grade												
Science as Inquiry	Identify questions and concepts that guide scientific investigations.	x	x	x	x	x				x	x	x
	Design and conduct scientific investigations.										x	
	Use technology and mathematics to improve investigations and communications.				x	x				x	x	
	Formulate and revise scientific explanations and models using logic and evidence.									x	x	x
Physical Science	Develop understanding of structure and properties of matter.	x	x	x	x							
	Develop understanding of interactions of energy and matter.			x	x	x				x	x	
	Develop understanding of energy in the earth system.			x	x	x	x	x	x	x	x	x
Earth and Space Science	Develop understanding of the origin and evolution of the earth system.						x	x	x			x
	Identify a problem or design an opportunity.										x	x
Science in Personal and Social Perspectives	Develop understanding of science and technology in local, national, and global challenges.										x	
	Develop understanding of science as a human endeavor.					x				x	x	x

Assessing Current Preconceptions & Misconceptions

- What do your students know and understand about white light and the frequencies of light?
- What do they know and understand about the Moon and current robotic space missions?

You may wish to spend some time during the activities or before beginning the activities discovering your students' current preconceptions of the topics to be presented. Education research has shown that many students have confused and naive concepts of light and color, and that their misconceptions may interfere with their learning. If you are able to address your students' misconceptions, you are much more likely to meet your learning objectives and the students will be more likely to retain their new understanding.

Common misconceptions about light

Research shows that students in middle school through college have misconceptions regarding light and the electromagnetic spectrum. These misconceptions include:

- An object is seen whenever light shines on it, with no recognition that light must move from the object to the observer's eye.[1]
- We see by the act of looking (visual ray idea), and not by light being reflected to our eyes.[1,2]
- Light is reflected away from shiny surfaces, but light is not reflected from other surfaces.[1]
- Different forms of light include "natural," "electric," "ultraviolet," and "radioactive."[3]
- When light passes through a prism or a filter, color is added to the light.[4]
- Color is a property of an object, not affected by the illuminating light.[5]

There are also misconceptions regarding NASA's exploration of the Solar System. Some students may believe that humans have never been to the Moon7, while others may believe that astronauts have visited many of the planets in the Solar System. Students may not be aware of past or ongoing scientific robotic missions to our Moon and other planets.

To determine your students' current understanding of light, conduct at least one of the following activities, if not both.

[1]Guesne, E. (1985). Light. In R. Driver, E. Guesne, & A. Tiberghien (Eds.), *Children's ideas in science* (pp. 10-32). Milton Keynes, UK: Open University Press. Fetherstonhaugh and Treagust (1992)

[2]Watts, D.M. 1985. Students' conceptions of light-a case study. *Physics Education* 20: 183-187

[3]Zylbersztajn, A. and Watts, D.m. (1982) *Throwing Some Light on Colour* Mimeograph, University of Surrey

[4]Driver, R., A. Squires, P. Rushworth, and V. Wood-Robinson. 1994. *Making sense of secondary science: Research into children's ideas.* London and New York: RoutledgeFalmer.

[5]Anderson, C. and Smith E. (1986) Children's Conceptions of Light and Color: Understanding the Role of Unseen Rays. Research Series No. 166.

EDUCATOR

1.1 Writing Preassessment: The Story of a Bit of Light

In this 20-minute activity, students complete a story about light. The teacher will then examine their stories for key concepts and misconceptions regarding how we see and the role of light in seeing, using the rubric provided.

Outcomes

The teacher will be able to use the results of this activity to better understand his or her student's misconceptions of sight, as well as document student growth in conceptual understanding through the writing rubric provided.

Key Concepts

- Light travels or moves until it is reflected or absorbed by an object.
- Light can be reflected, or "bounce" off of any object (not just mirrors).
- In order for a person to see something, light must be reflected off of that object and into his or her eye(s).

Materials for each student:

- One copy of the *Story of the Little Bit of Light*
- Pen or pencil
- Colored pencils

Assessment Activity

1. **Hand out copies of the Story of the Little Bit of Light to your students.** Let them know that this science writing activity is for you and that their work will not receive a grade—this is not a test.
2. **Let the students know they have 15 minutes to write the rest of the story.** Their assignment is to write what happens to the light. What does it do? Where does it go so that the student in the photo can see the book or map? Remind the students that this is a science writing exercise; you would like a scientific story about the light, not a fictional story.
3. **At the end of 15 minutes, collect the students' work.** Outside of class, examine the stories for indications that the students understand that light keeps moving (instead of stopping), that the light reflects or hits objects, and that it does travel to the child's eyes in order for him or her to see. Use the rubric provided to assess student scores. Make note of common misconceptions and preconceptions.
4. **Keep your students' misconceptions in mind while conducting the activities in this guide and address them throughout the activities.** If there is substantial confusion as to how we see, consider additional discussion and activities about sight and seeing before conducting the activities in the modules.
5. **Re-apply this assessment after the students further explore light, the electromagnetic spectrum, and how we (humans) see, to assess if there has been an increase in their understanding of these concepts.**

STUDENT
Pre/Post Assessment

Student Name: _____
Date:_____ Class Period:_____

Writing Preassessment: *The Story of a Bit of Light*

Instructions: Pick one of the images and complete the following story about light. Your story should include how or why the student in the photo can see the object.

I am a little bit of light. I was formed by the sun . I moved through space and the Earth's atmosphere and then I … _____

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EDUCATOR

Writing Preassessment: The Story of a Bit of Light

Rubric for "A Little Bit of Light Story"

	Light travels in straight lines from a source.	**Light travels outward in all directions from a source.**	**After light bounces off an object, it travels in a straight line in a new direction.**
Beginning	Does not explain that light travels	Is unable to explain that light travels outwards in straight lines in all directions	Is unable to explain that light bounces or travels in straight lines
Developing	Is able to demonstrate that light travels from a light source but does not understand that it travels in a straight line	Is able to demonstrate that light travels outward from a light source but does not describe that it travels in all directions.	Is able to demonstrate that light bounces off objects, just not in straight lines in new directions
Proficient	Describes how light travels in straight lines from a light source	Describes how light travels outward in all directions from a light source	Describes how reflected light travels; bouncing off an object in a straight line in a new direction
Advanced	Understands at a proficient level and shows interest in investigating the path of light in everyday situations	Understands at a proficient level and applies understanding to control how light travels from a source.	Understands at a proficient level and applies understanding to real-world scenarios. (For example, such as light bouncing off a glass)

STUDENT

Pre/Post Assessment

Student Name: _____

Date:_____ Class Period:_____

1. **Which phrase best describes electromagnetic radiation?**
   A. Visible light
   B. Gamma rays
   C. Reflection
   D. Waves of energy

2. **Which is NOT part of the electromagnetic spectrum?**
   A. Radio waves
   B. Microwaves
   C. Water waves
   D. X-rays

3. **Which phrase best describes the most powerful EM radiation?**
   A. Longer wavelength
   B. Shorter wavelength
   C. X-ray
   D. Radio wave

4. **The best definition of refraction is ____.**
   A. passing through a boundary
   B. bouncing off a boundary
   C. changing speed at a boundary
   D. changing direction when crossing a boundary

5. **Which of the following rocks are <u>NOT</u> found on the Moon:**
   A. Dunite
   B. Basalt
   C. Anorthosite
   D. Limestone

6. **Which color of visible light has the shortest wave-length?**
   A. yellow
   B. green
   C. blue
   D. violet

7. **Which of the following places waves from longest to shortest:**
   A. Gamma ray, x-ray, ultraviolet, visible, infrared, microwave, radio
   B. Visible, radio, microwave, infrared, ultraviolet, x-ray, gamma ray
   C. Gamma ray, x-ray, ultraviolet, infrared, microwave, radio, visible
   D. Radio, microwave, infrared, visible, ultraviolet, x-ray, gamma ray.

8. **Spectroscopy is:**
   A. The study of objects based on the spectrum of color they emit or absorb
   B. An important investigative tool in astronomy
   C. Used to analyze the properties of distant objects
   D. Tells scientists the age of relative objects

9. **Infrared spectroscopy is useful to obtain information about:**
   A. Waves of radiation smaller than visible rays
   B. Waves of radiation associated with heat
   C. Waves of radiation associated with using radios
   D. Waves of radiation associated with using nuclear power

10. **Colored filters _____.**
    A. Absorb some of the colors of light and only allow a few of the colors to pass through
    B. Allow you to see all colors but turn everything the color of the filter
    C. Allow you to see all colors but turn everything a secondary color on the color wheel
    D. Do not change the light