Garden Spies

Standards:

Georgia Performance Standards in Science
S8CS2.a, b; S8CS4.a, b; S8CS6.a, c; S8CS9.a, b, e, f; S8P4.a-d
Next Generation Science Standards
PS4.B
Common Core Literacy Standards
ELACC6-8RST3, ELACC6-8RST4, ELACC6-8WHST9

Supplies:

For Reflection of Light Rays Activity
Per group of 4 students (8 groups)
1 Flat mirror approx. 2" x 2"
1 mirror support (clips, clothes pins, etc.)
1 ruler with cm marks
1 protractor;
4 straight pins (from one box of 100 pins for class)
Bring Your Own
BYO: laser pointer (optional)
BYO: paper
BTO: pencil

(For Periscope Activity)
Per student
Doctor transparent tape;
scissors
2 small mirrors (approx 2" x 2")
BYO: cardboard box (e.g. cereal box) or paper towel roll
BYO: scissors
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Garden Connection:

Students will observe and analyze plants and wildlife in the garden using a handmade periscope and possibly also Infragram cameras.

Technology:

Students will complete an engineering design challenge where they will design and create their own periscopes to view plant and animal life in the garden.

Overview

Students will observe wildlife and analyze images in the garden by making and using periscopes and other image-capturing devices which work because of light reflection and refraction of angles. Students can also create hyperlapse videos using cameras or smartphones. Infragram is an online tool for analyzing plant health with near-infrared imagery.

Essential Questions

How can I bend, reflect, and refract light by building tools I can use to capture images in the garden?

Engage

Have students brainstorm what produces light, what we use light for, and how light travels. Elicit students' understanding about what reflection and refraction are and address any misconceptions. Conduct one of the Law of Reflection activities detailed in the lesson plan

Explore

- Have students work in groups to explore the Law of Reflection by building a periscope that they will use to observe and analyze plants and wildlife in the garden. You can also add an engineering design challenge at the end for students to modify the design and build better periscopes.
- Students can also use cameras and smartphones to create hyperlapse videos of organisms they observe in the garden. These videos can be uploaded to YouTube, Vimeo, Instagram, a classroom webpage, etc.

Explain

Students will be able to explain how they made/used various instruments used to view plants and animals in the garden, trace the pattern of light through each, explain how they work, and explain how they can be useful in the garden.

Environmental Stewardship

Students will use wildlife viewing to confirm or refute predictions of what animals eat from the school garden and how they behave.

Evaluate

A rubric is provided to assess student mastery of performance expectations.

Extend

Students may contribute to Public Lab's Infragram citizen science projec

Standards

GEORGIA PERFORMANCE STANDARDS IN SCIENCE

S8P4. Students will explore the wave nature of sound and electromagnetic radiation.

a. Identify the characteristics of electromagnetic and mechanical waves.
b. Describe how the behavior of light waves is manipulated causing reflection, refraction diffraction, and absorption.
c. Explain how the human eye sees objects and colors in terms of wavelengths.
d. Describe how the behavior of waves is affected by medium (such as air, water, solids).

NEXT GENERATION SCIENCE STANDARDS

PS4.B: Electromagnetic Radiation

When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2)

The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (MS-PS4-2)

A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. (MS-PS4-2)

COMMON CORE LITERACY STANDARDS

FELACC6-8RST3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

ELACC6-8RST4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.

ELACC6-8RST9: Compare and contrast the information gained from experiments, simulations, video or multimedia sources with that gained from reading a text on the same topics.

Teacher Background Information

Reflection

- Just as heat and sound travels, so does light. Light travels in straight lines, but sometimes it bounces off of objects. This is called reflection. As light travels through matter, different amounts of that light penetrate through the matter. Transparent objects allow nearly all of the light shined on it to pass through the object. Glass, air, and clear plastic are transparent objects. Translucent objects allow some of the light to pass through it while some of the light is absorbed. Wax paper and tissue paper are translucent and light that transmits through them is scattered and fuzzy. Opaque objects absorb or reflect all of the light and do not allow any light to pass through them. Brick, stone, and metals are opaque. Materials that are very dense tend to be opaque & objects that are not dense tend to be more transparent.

- Reflection of light occurs when light hits a smooth surface that does not absorb any of the light but instead bounce it back off the surface. A mirror is flat, smooth, and polished. When light hits a mirror, it is not absorbed but is reflected off at a very predictable angle. The angle that the light hits the mirror is called the angle of incidence. The angle of light that bounces off the mirror is called the angle of reflection. The Law of Reflection states that the angle of incidence is equal to the angle of reflection.

- When light hits an object that is uneven, granular, or bumpy, the reflected light rays that bounce off scatter in many directions. These objects do not produce reflections that are recognizable like a mirror does. When an image is reflected off a mirror, the image appears to the person seeing it as backwards.

For more information about reflection, see the websites listed below:

» http://www.pegasuslighting.com/reflection-and-refraction-of-light.html
» http://www.optics4kids.org/home/content/what-is-optics/reflection/the-reflection-of-light/
» http://www.physicsclassroom.com/class/refln/Lesson-1/The-Law-of-Reflection
» http://water.me.vccs.edu/courses/env211/lesson15_2.htm

Refraction

- Refraction is one of many characteristics of light. Usually light travels in straight lines, but it bends as it passes from a medium of one density to a medium of different density. Light bends because it travels at different speeds through media of differing densities. Light, as it moves through air, travels 186,000 miles per second. However, the denser the material that light is traveling through, the slower the speed will be. Light passes a lot slower through water, for example. Refraction of light can be seen by using a prism. The white light is separated into all of the colors of the rainbow. Mirages are also caused by refraction of light.

For more information about refraction, see the websites listed below:

- https://www.brainpop.com/science/energyrefractionanddiffraction/qanda_popup.weml?qanda_id=4103&character=Tim&character_ id=1

Periscopes

- A periscope is an optical instrument that uses a system of prisms, lenses, or mirrors to reflect images through a tube. A typical periscope uses two mirrors at 45 degree angles to the direction one desires to see. The light bounces from one to the other and then out to the person's eye. If the mirrors are parallel to each other, the periscope "looks" forward and the object seen is right side up. If the mirrors are set at right angles to each other, the periscope "looks" backward and the object seen is upside down. In high-quality periscopes, reflecting prisms are often used instead of mirrors.
- A periscope is designed to allow a person to see around an object or through a wall. Often used by the military, periscopes allow people to look at things without putting themselves in danger. Periscopes are often used by the army to see above or around a wall or obstacle. Periscopes in the navy are used on submarines to allow the crew to see above the water, without having to surface the whole sub.

For more information about refraction, see the websites listed below:

- http://www.wisegeek.org/what-is-a-periscope.htm
- http://www.webinnate.co.uk/science/week8.htm
- http://sciencenetlinks.com/lessons/seeing-around-corners/
- http://www.answers.com/Q/How_does_a_periscope_work

Infagram Technology

- Infragram is an online tool for analyzing plant health with near-infrared imagery. Images can be uploaded from an Infragram-modified camera or USB Infragram webcam or a camera over which a red or blue filter has been taped.
- An "infrablue" image is one in which the "red" channel of the image shows "near-infrared" light instead of the usual red. Such images can be generated using many inexpensive digital cameras and webcams by removing the infrared block filter and then adding a filter that selectively blocks red light (this is something Public Lab kits accomplish).

For more information about infrared and infrrablue images, see the websites listed below:

- https://www.kickstarter.com/projects/publiclab/infragram-the-infrared-photography-project
- http://infragram.org/
- http://publiclab.org/wiki/near-infrared-camera
- http://publiclab.org/wiki/infragram
- http://store.publiclab.org/collections/diy-infrared-photography

Information for Student Research

- *"Pollinators – Putting Food on the Table."* http://vimeo.com/77811127
- *"How Light Travels"* - http://www.pbslearningmedia.org/resource/lsps07.sci.phys.energy.lighttravel/how-light-travels/ (1:57)
- *"Light and the Law of Reflection"* - http://www.pbslearningmedia.org/resource/lsps07.sci.phys.energy.lightreflect/light-and-the-law-of-reflection/ (5:36)
- *"Refraction of Light Demonstration"* - http://www.pbslearningmedia.org/resource/lsps07.sci.phys.energy.refractdemo/refraction-of-light-demonstration/ (demo; no time frame specified)
- *"Light Absorption, Reflection, and Refraction"* - http://studyjams.scholastic.com/studyjams/jams/science/energy-light-sound/light-absorb-reflect-refract.htm (3:18)
- *"Make a Periscope!"* - https://www.youtube.com/watch?v=qVaR16Kov8s (3:03)
- *"How to Make a Periscope"* - https://www.youtube.com/watch?v=8TzXN5gunFg (6:26)
- *"Periscope at Home"* - https://www.youtube.com/watch?v=sChQZvPY3S4 (1:57)
- *Hyperlapse app (Apple):* https://itunes.apple.com/us/app/hyperlapse-from-instagram/id740146917?mt=8
- *Hyperlapse app alternatives (Android):* http://petapixel.com/2014/10/05/3-hyperlapse-alternatives-android-users-feeling-left-instagram/
- For more information about refraction, see the websites listed below:
  - https://www.youtube.com/watch?v=Dn3ruksNDGI (2:20)
  - https://www.youtube.com/watch?v=lQJVfHInWQ4&feature=youtu.be (1:20)
  - https://www.youtube.com/watch?v=Arhlh1lzjp8 (2:51)
  - https://www.youtube.com/watch?v=tlNjLwcbitI (2:20)
  - Camera: https://www.youtube.com/watch?v=RmGPvSbqkcE (12:12)

Teacher Preparation

Print and copy the student pages for the labs and activities of your choice. Gather the materials needed to build the periscopes. Print and copy student instructions for assembly.

Engage

- Have students brainstorm what produces light, what we use light for, and how light travels. Elicit students' understanding about what reflection and refraction are and address any misconceptions.
- Refer students to the NASA website on behaviors of light: http://missionscience.nasa.gov/ems/03_behaviors.html and other Student Research web sites identified above.
- Allow teams of students to conduct research using Internet connected computers.
- Students may also complete any or all of the following activities:

  Reflection of Light Rays
  Complete Activity 4-1 from University of Virginia Physics Dept http://k12.phys.virginia.edu/Labs/Lab04.pdf; pp. 1-6)
  Verifying the Law of Reflection
  (Activity 4-3 from the University of Virginia Physics Department http://k12.phys.virginia.edu/Labs/Lab04.pdf; pp. 12-15)
  Bending Light
  From "Bending Light" by Teresa Hislop and Kirsten Reed via the Utah Education Network:
  http://www.uen.org/Lessonplan/preview?LPid=2339
  Bending and Bouncing Light (Magic Penny; Spoon in a Glass; and Bending Rays)
  From "The Bending and Bouncing of Light" by Joyce Brumberger via the Akron Global Polymer Academy:
  http://www.agpa.uakron.edu/p16/module-print.php?id=bending_bouncing_light)

- Challenge teams of students to explore various materials with the goal of demonstrating and explaining the following:
  - Reflection
  - Refraction
  - Absorption
  - Transmittance

Explore

Have students work in groups to explore the Law of Reflection by using a recycled box or paper towel roll to build a periscope for stealthily observing plants and wildlife in the garden around corner and over walls.

- *Directions for how to build a simple periscope from:*
  http://www.planet-science.com/categories/under-11s/our-world/2012/06/make-a-periscope.aspx
  - Materials: cardboard, duct tape, scissors, and small mirrors
  - Make a tall, rectangular tube out of your cardboard. The ends should be left open. Use one of the small mirrors to see how wide your tube needs to be. Use duct tape to secure your cardboard tube.
  - Cut a flap on opposite ends and sides of your box. This flap should be the same height as your mirrors.
  - Tape a mirror to the inside of each flap.
  - Cut away the side of the cardboard opposite each flap.
  - Angle both mirror flaps inward about 30 degrees. Look through the bottom of the periscope to see that what is seen on the top mirror is also reflected on the bottom mirror.
  - Secure the mirror flaps with duct tape once you're happy with the angle.
  - Now you can look round corners and over walls! Is there a way to improve your periscope? Could you use a longer tube? How about camouflaging it?

- *Directions for how to build a paper towel periscope from:*
  http://www.ehow.com/how_7701793_make-periscope-paper-towel-roll.html:
  - Materials: scissors, 2 paper towel rolls, 2 small hand-held mirrors, and tape.
  - Use the scissors to cut a circular hole in the side of one paper towel roll about 3/4 of an inch from the end. The hole should be the same size as the diameter of the paper towel roll. Cut another hole of the same size in the opposite side and opposite end of the paper towel roll.
  - Cut off each end of the paper towel roll at a 45 degree angle so that the longer portion of the roll at each end still contains the circular hole. When a mirror is held up against the cut end, you should be able to look in the circular hole and see down the inside of the paper towel roll.
  - Tape a mirror to each 45 degree opening of the paper towel roll. You should be able to look into one of the circular holes and see out the other circular hole.
  - Cut the other paper towel roll in half then tap each half to the circular holes of the other paper towel roll.

- Alternative directions for periscope assembly:
  - https://www.exploratorium.edu/science_explorer/periscope.html
  - http://www.nasa.gov/pdf/350528main_Optics_Making_a_Periscope.pdf
  - http://www.wikihow.com/Make-a-Periscope
  - http://www-tc.pbskids.org/zoom/printables/activities/pdfs/periscope.pdf:

Explain from Evidence

Use the questions and answers in the last part of this resource to engage students in making sense of phenomena related to the behavior of light: http://www.cpalms.org/Public/PreviewResourceLesson/Preview/76442 After dispelling any misconceptions during the class discussion, students should be able to explain how they made and used periscopes to view plants and animals in the garden, trace the pattern of light through each, and explain how they work.

Environmental Stewardship

Challenge teams of students to use their understanding of light – including how it is absorbed, reflected, refracted or transmitted – to create an improvement or exhibit for the school garden, complete with an explanation of how and why it works? For instance, could periscopes allow you to build and see around a cardboard bird or wildlife blind, to view garden critters without scaring the away? Could knowing what colors absorb light affect how you might warm up the soil at the end of winter, in a seed starting area? Could knowing that light speed changes, thus making it appear bent when it enters a medium of a different density, enable you to create an optical illusion in the garden? Could you direct light through an obstacle course of foil reflective surfaces until it reaches and spotlights a particular plant in the garden?

Evaluate

A rubric is provided for assessing student mastery of performance expectations.

Extend

Students may use their periscopes and cameras (or cell phones) to capture images in the school garden. Students may also explore other ways to create images from the garden.

Infragram Images

- Students may contribute to Public Lab's Infragram citizen science project by reporting data and uploading infrared images of plants using a modified camera or by connecting a USB cable to an Infragram webcam. Students will use wildlife viewing to confirm or refute predictions of what animals eat from the school garden and how they behave.
- http://publiclab.org/wiki/infragram

Spectroscopy

Students may explore spectroscopy with CalTech's interactive Whyville spectrometer:
http://coolcosmos.ipac.caltech.edu/cosmic_games/spectra/spectrometerTutorial.htm

Make a spectrometer that uses an old CD as a diffusion grating to refract light, with this template from Public Lab:
http://publiclab.org/wiki/foldable-spec

Or these instructions from CalTech: http://coolcosmos.ipac.caltech.edu/cosmic_games/spectra/makeGrating.htm

Hyperlapse Videos

- Hyperlapse films can be created in the garden to collapse time and make an activity appear to speed up. Here are some links to information on making hyperlapse films:
- » http://blog.instagram.com/post/95829278497/hyperlapse-from-instagram (0:46)
- » http://vimeo.com/tag:hyperlapse (various videos on this page)

Garden Spies

Grade: *8* **|** ***Time:*** *(2-3) 50 minute periods*

Name: ***Date:*** ***School:***

Level of Mastery Benchmark or Performance Measure	 **EMERGING** **Not yet proficient** **1 point**	 **COMPETENT** **Partially proficient** **4 points**	 **PROFICIENT** **Mastered task** **5 points**
Lab Experiments/Activities	Student demonstrated and explained one or two of these light behaviors: reflection, refraction, absorption and transmittance	Student demonstrated and explained three of these light behaviors: reflection, refraction, absorption and transmittance	Student demonstrated and explained all of these light behaviors: reflection, refraction, absorption and transmittance
Making Models (Periscope)	The finished model is incomplete or does not work and/or the student cannot explain the scientific principles behind its functionality.	The finished model is adequately put together and the student can somewhat explain the scientific principles behind its functionality.	The finished model is well put together and the student can thoroughly explain how it works, using the words reflect,
Camera Images, Hyperlapse Videos (optional)	n/a	n/a	Student took pictures or videos of garden plants or animals
Citizen Science Project (optional)	n/a	n/a	Participated in the Infragram citizen science project (taking, uploading, and analyzing pictures).